EXHIBIT 33

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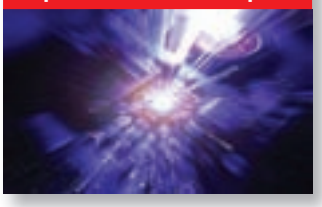
Enhancing PV absorption

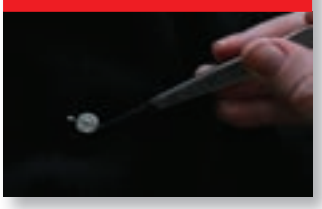
AMEC sets sights on GaN lighting

Hybrid silicon to replace InP chips



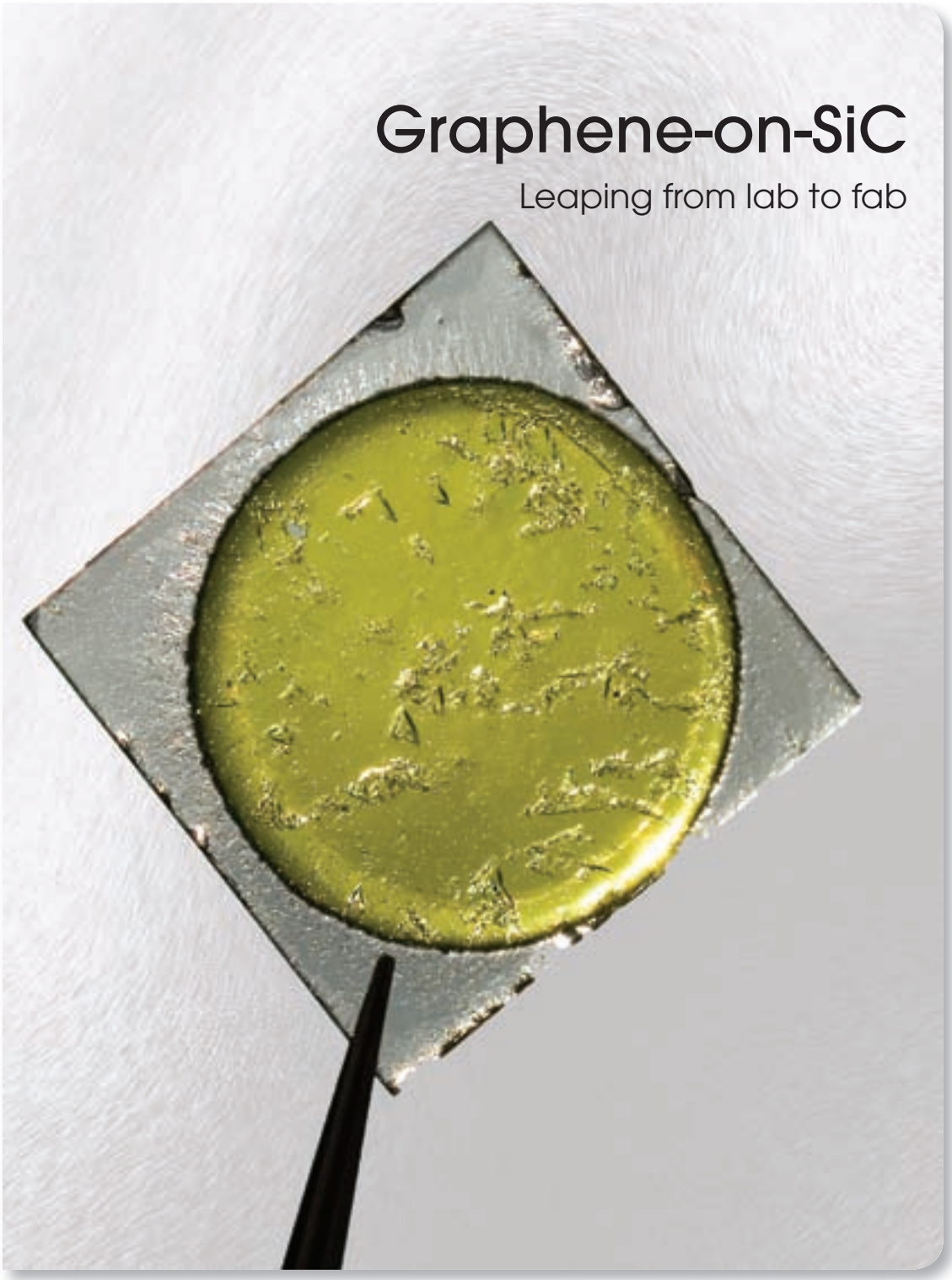
Slashing the cost of LED lighting

Efficiency hike for ultraviolet LEDs



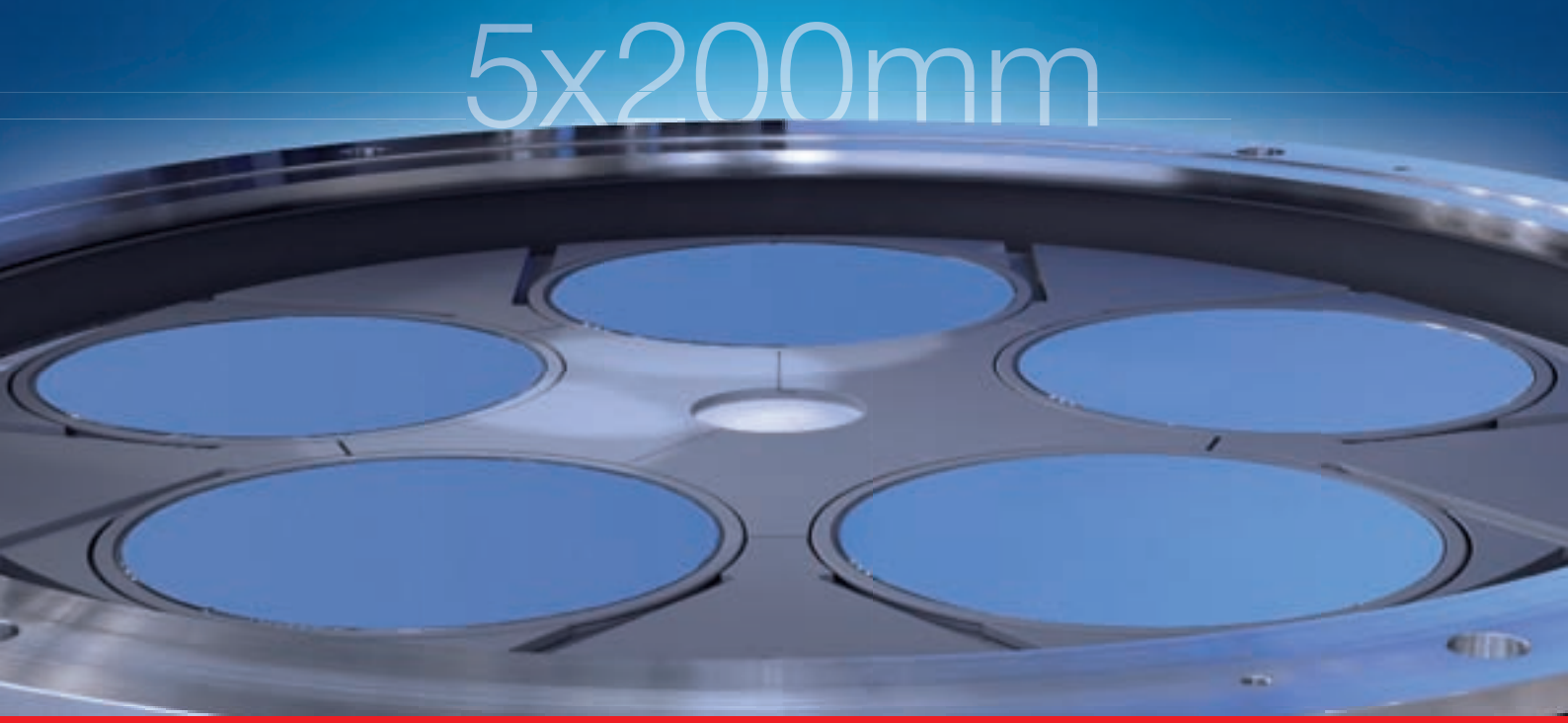
Graphene-on-SiC

Leaping from lab to fab



AIXTRON

200mm GaN-on-Si Batch Reactor



AIX G5+

AIX G5+ for GaN-on-Si

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- Enables Si-style mass manufacturing
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  using standard Si substrates.

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ALWAYS ONE STEP AHEAD

editorial view

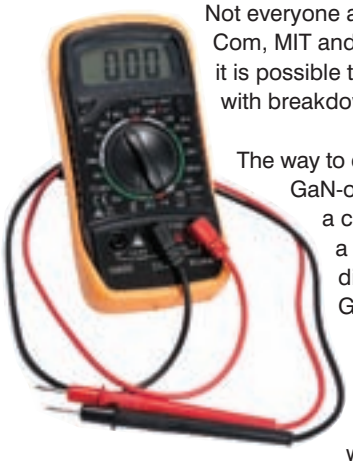
by Dr Richard Stevenson, Editor

The wide bandgap war

WIDE BANDGAP POWER ELECTRONICS is the hottest sector within our industry. Sales in this market are tipped to rocket throughout the foreseeable future, leading to annual revenues for SiC and GaN devices to hit around $1 billion or more by 2020.

At the hugely successful CS International, which was held this March, a high proportion of presentations detailed advances in both classes of transistor and diode, and leading analysts predicted where these devices could make an impact.

In the long-term, they'll see deployment in the grid. But they'll need a stepping-stone to get there, which could well be the solar inverter: The time taken to recoup the additional outlay over an all-silicon system is dropping from a few years to a matter of months, and this will spur sales of wide bandgap products in this sector.



Which widegap material has the greater success in a particular application may be decided by the maximum operating voltage of the device. At voltages below 1 kV, many believe that GaN-on-silicon devices will be more successful than their SiC cousins, due to a combination of lower cost and superior performance to silicon equivalents. But beyond 1 kV, SiC is tipped to dominate, because it is felt that GaN-on-silicon cannot handle such high voltages.

Not everyone agrees with this view. A partnership from M/A Com, MIT and the US Department of Energy has shown that it is possible to construct GaN-on-silicon diodes and HEMTs with breakdown voltages well in excess of 2 kV.

The way to do this, which is detailed in the feature "Boosting GaN-on-silicon blocking voltages" (see p42), is to use a combination of sophisticated buffer layers and a field plate. Note that it is crucial to optimise the dimensions and location of this plate to enhance GaN-on-silicon performance.

This project has used commercially produced, 100 mm, GaN-on-silicon epiwafers, highlighting that this combination can combine low costs with high levels of performance.

It will be interesting to see how quickly it takes for high-voltage devices made in this way to appear on the market, where they can compete with silicon incumbents and a handful of SiC products. I, for one, will find it intriguing to watch how the battle for the power electronics market pans out over the next decade.

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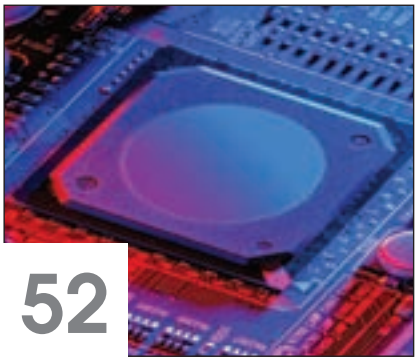

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Magazine & Front Cover: Designed by Mitch Gaynor

Plessey releases first 6-inch GaN-on-silicon LED products

PLESSEY has announced that samples of its GaN on silicon LED products are now available. The company says these entry level products are the first LEDs manufactured on 6-inch GaN-on-silicon substrates to be commercially available anywhere in the world.

Plessey is using its proprietary large diameter GaN on silicon process technology to manufacture the LEDs on its 6-inch MAGIC (Manufactured on GaN I/C) line at its Plymouth, England facility. The use of Plessey's MAGIC GaN line using standard semiconductor manufacturing processing provides yield entitlements of greater than 95 percent and fast processing times providing a significant cost advantage over sapphire and SiC based solutions for LEDs of similar quality.

The release of the availability of Plessey's GaN on silicon LEDs was coincident with a visit to the Plessey Plymouth facility by the Rt. Hon. Vince Cable, MP, Secretary of State for Business Innovation and Skills and President of the Board of Trade.

Business Secretary Vince Cable comments, "The government is supporting innovative companies like Plessey who are growing, creating jobs and exporting their products all over the world. That's why we selected Plessey's £3.25 million Regional Growth Fund bid for Government support, which will create 100 new, high tech and highly skilled jobs in the region."

Michael LeGoff, CEO Plessey says, "We are very pleased to welcome Secretary of State Vince Cable today. The department of Business Innovation and Skills has been very supportive of our efforts to date and with the launch of our first range of LEDs today we are now looking towards aggressive growth in the solid state lighting markets."

"Today is a significant step for us" adds Barry Dennington, Plessey's COO. "From acquiring our first MOCVD reactor in August 2012 to having our first product in April 2013 is excellent progress. These entry level products will be used in indicating and accent lighting

applications." We will continue to make progress in output efficiency and are on plan to release further improvements in light output throughout this year and into next. The operating and unit costs are on plan and we are seeing a number of routes to enhance our cost advantage over competing technologies," continues Dennington.

The MAGIC LED technology was transferred from Cambridge University with the help of Dandan Zhu from the Cambridge Centre for Gallium Nitride, Simon Westwater and Antoine Pujol from Plessey Semiconductors. At Cambridge, the LEDs are grown on a 6 x 2" Thomas Swan (now Aixtron) reactor, whereas at Plessey, they are grown on an Aixtron CRIUS II-XL 7 x 6" platform.

LEDs and the associated solid state lighting solutions are due to become the dominant form of lighting in all forms in within the next five years.

Solid state lighting is an energy efficient eco-friendly technology that will save billions of tons of carbon emissions when fully implemented.

There are also no recycling issues that fluorescent lighting poses with mercury content.

Spectrolab non-concentrator cell raises the bar

SPECTROLAB has achieved a solar cell efficiency of 37.8 percent without concentration. This is the common practice of having lenses or mirrors focus solar rays on the cells.

This world record in ground-based solar cell efficiency was verified by the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colorado. The cells use a new class of high-efficiency multi-junction solar cell, created from two or more compound semiconductors, leveraging Boeing technology that makes such materials more reliable.

"We expect this solar cell technology will have significant benefits for space, ground-based, and sensor applications," says Troy Dawson, president of Spectrolab.

Spectrolab believes this solar cell technology can attain higher levels of efficiency, "possibly more than 45 percent even under low concentrations," according to Nasser Karam, the company's VP for advanced technology.

Spectrolab, which is part of the Boeing Defence, Space & Security unit, is a merchant supplier of high-efficiency multi-junction solar cells and panels for concentrated photovoltaic and spacecraft power systems. Spectrolab offers sensors and solar simulators, in addition to being a provider of airborne searchlights.

Avago to acquire InP innovator CyOptics

ANALOGUE INTERFACE component supplier Avago Technologies has signed a definitive agreement to acquire CyOptics.

CyOptics specialises in InP optical chip and component technologies for the data communications and telecommunications markets.

The aggregate acquisition price will be approximately US$400 million in cash. Avago's optical transceiver products primarily utilise VCSEL-based technology. Avago believes the acquisition of CyOptics will strengthen its fibre optics product portfolio for emerging 40G and 100G enterprise and data centre applications.

CyOptics' single-mode InP laser, receiver and photonics integration capability will help extend Avago's technology in these applications. The acquisition of CyOptics will facilitate Avago's establishment of a complementary optical components business, not only to serve growing segments of the access, metro and long-haul markets, but also for enterprise and data centre segments.

CyOptics designs, fabricates and packages a broad portfolio of optical component products across enterprise, data centre, access, metro and long-haul market segments.

CyOptics' optical components are integrated into optical transceivers, transponders and line cards. Leveraging its Bell Labs and Lucent heritage, CyOptics has built a broad product portfolio and a customer base that includes the leading module and system OEMs. The firm's revenues have more than tripled over the past three years.

"We believe CyOptics' leading InP technology and optical manufacturing capability will strengthen Avago's fibre optics portfolio and accelerate our ability to capture next generation 40G and 100G enterprise and data centre sockets," says Hock Tan, President and CEO of Avago.

"We are delighted to join Avago Technologies, a company with a long history of innovation and a strong position in the wired infrastructure market. We believe this transaction presents tremendous opportunities for our customers and our employees," adds Ed Coringrato, President and CEO of CyOptics. "I would also like to take this opportunity to thank our long standing investors, JVP and especially their founder, Dr. Erel Margalit, for their support and guidance over the past decade in building CyOptics into the significant industry participant it is today.

My gratitude as well to our recent partners, TA Associates, for their vote of confidence and support."

Philips and Optogan start LED production in Russia

THE GOVERNOR of Saint-Petersburg, Georgy Poltavchenko, and Anatoly Chubais, CEO and chairman of the Executive Board of Rusnano, has visited the production site of JSC Optogan in St-Petersburg, Russia.

This is where the joint venture (JV) "Philips and Optogan," have launched the production line of the brand new LED luminaire "Avenue".

The maximum capacity of the line is more than 50000 LED luminaries per year. The modern production line is capable of producing LED luminaries for street lighting according to the highest international quality standards, energy efficiency and reliability.

The visitors of the plant were demonstrated the brand new developments of "Philips and Optogan" for street and yard lighting, which allows the significant reduction of energy consumption without loss in light quality.

The new LED luminaire "Avenue" fits the whole range of economic and technical requirements of the Saint-Petersburg Energy Efficiency Program. This launch

allows "Philips and Optogan" to offer the "Avenue" at the most competitive price ever - 8000 rubles.Also the company experience of interacting with design bureaus strongly supports the usage of JV LED luminaries. They are claimed to perform "perfectly" even on A1 class highways, with the placement of the 20 metre lighting poles being 65 metres apart.

"We appreciate the interest and support of The Governor of St. Petersburg in the development of energy efficient technology in the region. We are satisfied that we have been able to present localised product families within such a short time which are fitting very well to Russian market requirements," Andre Richter, Head of "Philips and Optogan" comments. During the visit it was added that, "Indeed, this new LED luminaire will find a proper place in streets and yards lighting."

Royal Philips Electronics and Russian manufacturer of LED products Optogan, announced the signing of the joint venture agreement in April 2012. The JV aims to become a strong player in the fast growing LED road lighting market in Russia.

It took less than a year to launch the new production line at Optogan's production site in St-Petersburg.

During the year, "Philips and Optogan" significantly improved its product portfolio both economically and technically. Thus, the price for LED luminaries in 2013 decreased by 30 percent compared to the same kind of luminaries of 2012. This was coupled by a relative increase of energy efficiency of the luminaries of more than 10 percent. The Russian LED road lighting market is expected to double to EUR 100 million by 2015. The strategic initiatives of "Philips and Optogan" are totally in line with the company's plans to take a leadership position in the market.

First Solar's CdTe sets total area efficiency record

FIRST SOLAR has set a new world record for CdTe photovoltaic (PV) module conversion efficiency. The firm has achieved a record 16.1 percent total area module efficiency in tests confirmed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL).

The new record is a substantial increase over the prior record of 14.4 percent efficiency, which the company set in January 2012.

Separately, First Solar also set a record for CdTe open circuit voltage (VOC), a critical parameter for PV performance, reaching 903.2mV in NREL-certified testing. This new record marks the first substantial increase in CdTe VOC in over a decade of international R&D.
The new records come just six weeks after First Solar announced a new world record for CdTe solar cell efficiency of 18.7 percent.

Transferring its success in the R&D lab to its commercial modules, First Solar also launched a new evolution of its Series 3 thin-film PV module platform, the Series 3 Black. They incorporate First Solar's latest advances in conversion efficiency as well as additional features to enhance its performance in utility-scale power plants.

The all-black module's change in appearance results from the use of an advanced, all-black edge seal technology combined with an innovative encapsulation material that further enhances its field durability and demonstrates improvements in accelerated life testing results.

The Series 3 Black's performance in a wide range of operating environments is further validated by its new IEC 60068-2-68 "sand and dust test" certification, which measures durability in harsh desert environments characterised by blowing abrasive sand.

The certification complements existing IEC salt mist and ammonia certifications to provide a comprehensive range of independent testing that reflects world-class durability and performance in the harshest operating conditions.

The Series 3 Black module maintains all the existing IEC certifications and UL listings for the Series 3 family which enable the 1000V system designs that typify the company's utility-scale power plants. First Solar began to implement the Series 3 Black enhancements in production modules earlier this year.

Based on the company's record-setting technology and robust Series 3 Black platform, the company also has accelerated its module conversion efficiency roadmap, raising its lead production line module efficiency target for 2015 to 15-16.2 percent.

First Solar also extended its module conversion efficiency roadmap to 2017, with targets for lead production line module efficiency of 16.2 to 16.9 percent in 2016 and 16.4 to 17.1 percent in 2017. "We are especially proud of this new efficiency record because the technology was created for production-scale implementation, as evidenced by our accelerated efficiency roadmaps," says Raffi Garabedian, First Solar's Chief Technology Officer.

"Measurements in the lab are an important benchmark, but our R&D mission is to deliver technology that is designed to shine in real-world conditions as part of our integrated power plant systems, engineered to deliver the best performance, reliability and value for our customers. The Series 3 Black is a testament to our integrated approach to product development, combining technological advances from the lab with years of real-world data and experience operating utility-scale power plants in harsh environments."

Aledia's nano-LED research powers forward with Veeco

CEA-Leti, a research lab based in Grenoble, France, has selected Veeco's TurboDisc K465i MOCVD system for its program with Aledia, its nanowire-LED partner.

Aledia, a start-up company spun out of the CEA-Leti labs in 2011, is based at the CEA site. It counts among its three founders two former CEA researchers, Xavier Hugon and Philippe Gilet.

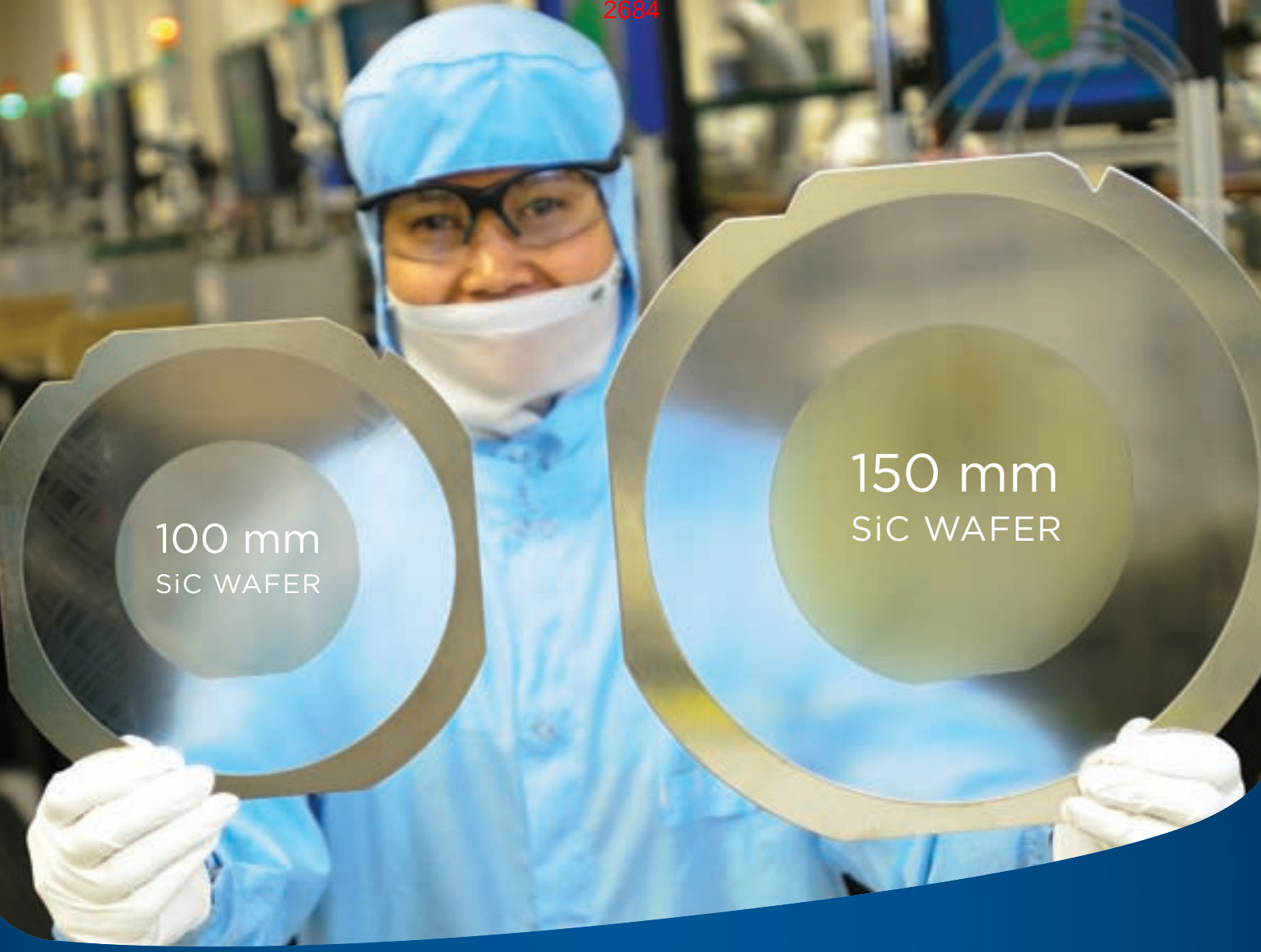
Aledia's goal is to manufacture 3D nanowire-based LEDs for solid-state lighting applications on thin silicon wafer substrates, of 8 inches or greater in diameter, at a cost significantly below that of conventional planar LEDs.

Nanowires are thin crystalline structures that, when electrically charged, can emit a broader spectrum of light than conventional LEDs, and can be grown on industry-standard silicon substrates.

Aledia's nanowire technology was originally developed at CEA-Leti, and Aledia and CEA-Leti continue to develop nanowire technology in close cooperation.

Fabrice Geiger, Head of CEA-Leti's Silicon Technology Division, comments, "We are confident that Veeco's MOCVD system is the right equipment to help make this technology successful."

According to Giorgio Anania, Aledia's President and Chief Executive Officer, "The TurboDisc reactor will be an important element of our strategy to take this potentially game-changing technology towards the commercialisation phase. In partnership with CEA-Leti, we selected Veeco because our analysis indicated that at this time their MOCVD systems showed the best financial returns for 8 inch wafer production on the market."



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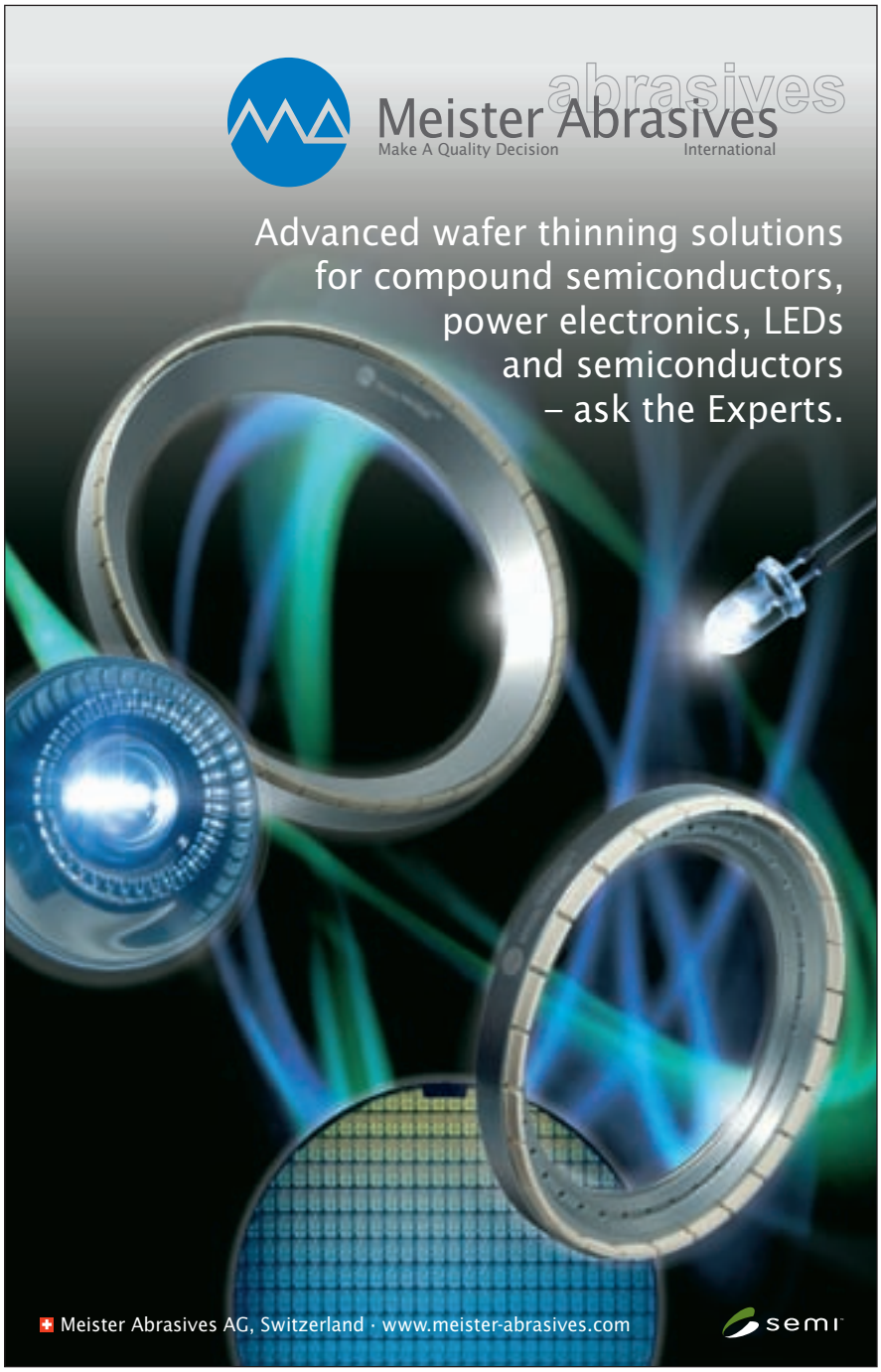
Nitride semiconductors set a new benchmark for UV LED output power

NITRIDE SEMICONDUCTORS has released a portfolio of ultra-high power, ultra-violet LEDs delivering output powers that can be in excess of 3W. One of these LEDs, the NS380L-6SVR, produces 3200mW at 380 nm. According to Nitride Semiconductors, the output of this LED at this wavelength exceeds all other commercial devices based on a single chip. Nitride Semiconductors has also launched a range of longer wavelength cousins, such as the NS400L-6SVR, which delivers an output of 3200mW at 400nm. The new range of chips combines an operating voltage of 4V with very high efficiencies. For example, driven at 800 mA, the NS380L-5SVR produces 700 mW at 380 nm, equating to an external quantum efficiency of 35 percent. Meanwhile, the 400 nm-emitting equivalent, the NS400L-5SVR, delivers an external quantum efficiency of 38.7 percent when driven at 1000mA, and emitting 1200mW. Typically, ultraviolet LED chips have dimensions of around 1 mm by 1mm. For example, those made by SemiLEDs are 1.2 mm square, while those produced by Nichia are 1mm square. In contrast, Nitride Semiconductors' ultraviolet LEDs are 2.2 mm square - they are claimed to be the biggest on the market.



Scaling the size of the chip while maintaining its performance is not trivial. Although increases in the chip's size boost output, efficiency is often compromised, due to heating issues and inferior current spreading within the device.

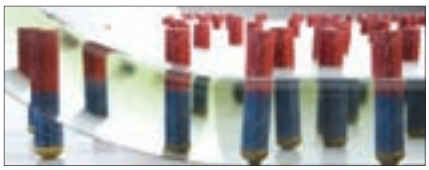
To address these issues, the engineers at Nitride Semiconductors produce their UV LEDs in a different way. They have developed a new layer structure to release the heat efficiently and introduced an electrode designed to flow current uniformly. This has been accomplished by minimising crystal defects through optimisation of epitaxial growth, and developing a vertical chip design with an optimal electrode pattern.

The large size of these devices enables the company to produce a single-chip ultraviolet LED with an output of several Watts; competing designs tend to be based on multiple chips. According to the company, the benefits of a single chip design include simplification of optics and a low driving voltage - when multiple chips are used, they are connected in series.

Ultra-violet LEDs are packaged in a surface mounted device format, and available in three sizes, ranging from 4.2 mm square to 5.6 mm square. They are designed for good heat transmission, and because the thickness of package is only 1.3mm, they can be mounted in high density by reflow soldering. The range of LEDs, which have been produced at a manufacturing cost that is just one tenth of that of the previous generation of devices, will be available for sampling from April 2013. Reliability is quoted at 10,000 hours, and guaranteed for 1000 hours.

Sol Voltaics GaAs nanowires boost solar performance by 25 percent

SOL VOLTAICS has unveiled Sol*Ink*, an economical nanomaterial that the company promises can increase the efficiency of thin film solar modules crystalline silicon or by up to 25 percent or more.



This will lead to solar power plants and rooftop solar arrays that will generate far more electricity than today's best commercially available systems. The increase in efficiency will allow Sol*Ink* enhanced panels to deliver power at prices that competes directly against electricity from fossil fuel plants while improving the economics for manufacturers.

Global demand for solar energy is expected to grow from 29.8 gigawatts of new solar installations in 2012 to 50.8 gigawatts in 2016, according to Greentech Media.

"The best way to lower the cost of solar power is to raise the efficiency of solar modules," explains David Epstein, CEO of Sol Voltaics. Approximately two-thirds of the cost of commercial solar systems revolves around land, labour costs and other factors that solar developers can't directly control. By raising the efficiency of solar modules, we give solar manufacturers the opportunity to sell more valuable, higher margin products and solar developers the opportunity to generate more power at a lower price with essentially the same physical assets."

To date, Sol Voltaics has raised $11 million from private investors including Industrifonden, Foundation Asset Management of Sweden, Teknoinvest, Provider, Nano Future Invest and Scatec Energy of Norway.

The company has received additional public funding from the European Union, Vinnova, Nordic Innovation Centre, and others. Sol Voltaics will raise $10 to $20 million this year.

Sol Voltaic's strategy revolves around two fundamental technologies: GaAs nanowires, thin strands of material that constitute the active ingredient in Sol*Ink*, and Aerotaxy, an innovative process for producing nanowires created by company founder and Lund University professor Lars Samuelson.

GaAs has been used in solar technology for years because of its reliability and high conversion efficiencies. Orbiting satellites employ solar cells made from the material to power their internal systems. GaAs solar cells, however, typically cost far more to produce than crystalline silicon or thin film cells, thereby confining the material to niche market segments.

Sol*Ink* dramatically reduces the cost by minimising materials used; less than a gram of nanowires is added to crystalline silicon panels. With Sol*Ink* , module manufacturers can make commercially feasible, high efficiency GaAs solar modules or multi-junction solar modules combining GaAs and crystalline silicon. Sol*Ink* also enables light concentration without the use of optics or mechanical components. Nanowires need only cover a small portion of the surface area of a crystalline silicon or thin film solar cell to achieve substantially all of the benefits of adding GaAs.

In a research paper published in Science earlier this year, Lund University and Sol Voltaics researchers demonstrated that indium phosphide (InP) nanowires covering just 12 percent of the substrate surface produced a solar cell with an efficiency of 13.8 percent. The results were certified by the Fraunhofer Institute.

The phenomenon, called Wave Concentrated Photovoltaics (WCPV), combined with the other advantages of GaAs nanowires leads to ground-breaking performance for Sol*Ink*.

Toshiba unveils new diodes for it SiC power devices

TOSHIBA will manufacture Schottky Barrier Diodes (SBDs) as the first of its new line-up of SiC products.

The SBD is suited for applications that include power conditioners for photovoltaic power generation systems. SBDs can also act as replacements for silicon diodes in switching power supplies, where they are approximately 50 percent more efficient.

SiC power devices offer more stable operation than current silicon devices - even at high voltages and currents - as they significantly reduce heat dissipation during operation.

They meet diverse industry needs for smaller, more effective communications devices and suit industrial applications ranging from servers to inverters and trains to automotive systems.

Analysts estimate that the SiC power device market will grow to about 10 times the current scale by 2020. Toshiba aims to secure 30 percent market share in 2020 by strengthening its product line-up, starting with the launch of the new SBD.

Production is at Toshiba's Himeji Operations-Semiconductor in Hyogo Prefecture, Japan.

Aledia grows 3D GaN LEDs on 8 inch silicon

CEA-Leti spin off Aledia, has made its first GaN LEDs on 8 inch (200mm) silicon wafers. The cost of Aledia's LED 3D chips based on microwires is expected to be four times less than traditional planar (2D) LEDs.

Aledia has announced its first-round financing totalling €10 million (approximately $13 million) with US and European investors, which was closed in 2012. Aledia solves the important cost issue in the very large and growing LED market. The continued integration of LEDs into new applications, such as general lighting, depends on LEDs becoming available at substantially lower prices than today.

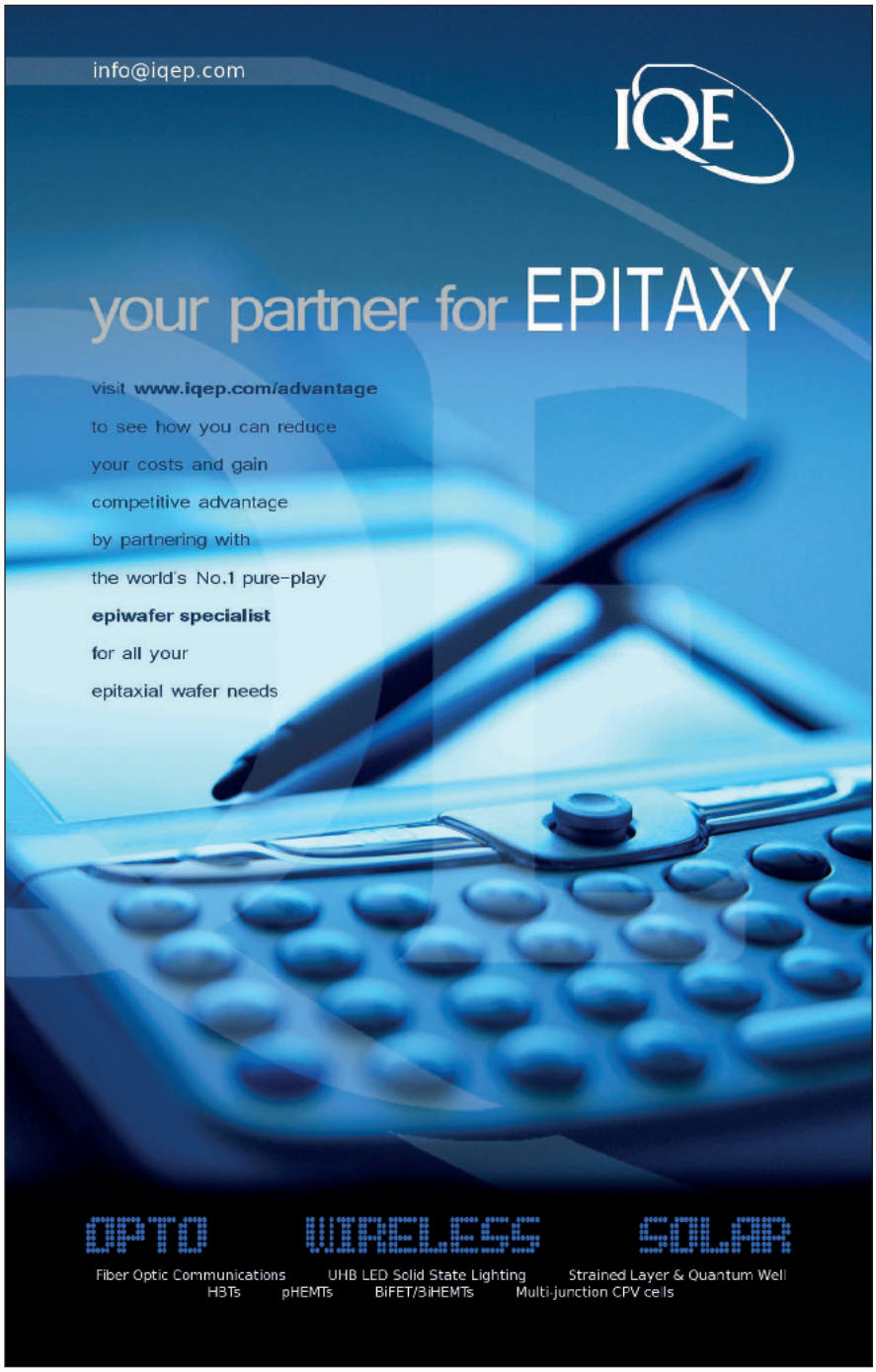
The company claims its microwire technology enables the steep cost reduction that is vital for the further transition to LED. The Aledia LED technology, made on large silicon wafers and with very low materials cost, represents a cost-disruptive solution to this problem. Also, the new LED technology is compatible with silicon CMOS technology and will be manufactured directly in existing high-volume silicon foundries.

"Since our financing last year, we have scaled up our microwire manufacturing process and transferred it to 8 inch (200mm) silicon wafers. We can now push forward to optimise the performance of these products and bring them to market," points out Giorgio Anania, Aledia co-founder, President and CEO.

Investors in Aledia's first-round financing included Sofinnova Partners, a European venture capital fund and an active investor in energy; New-York based Braemar Energy Ventures, a US energy technology investor with various investments in the LED and illumination area; Demeter Partners, a France-based cleantech investor; and CEA Investissement, the venture capital arm of CEA, France's Commissariat à l'Energie Atomique et aux Energies Alternatives.

"This is an innovative technology that can have a disruptive effect on the LED market," adds Jiong Ma, partner at Braemar Energy Ventures. "Braemar is committed to investing in companies like Aledia that have developed a breakthrough approach to LED lighting to accommodate a rapidly changing market. We are excited about the future opportunities this investment will bring and the expansion of Aledia's market presence and product offerings."

"We are proud to participate in the new venture of Giorgio Anania, a successful entrepreneur already well known to Sofinnova, and of an outstanding technical team, that could revolutionise the large and growing LED market, both in cost and performance," continues Alessio Beverina of Sofinnova Partners. "We believe that the development of LED lighting is an important element of energy-efficiency in our economies - lighting representing approximately 20 percent of all electricity usage. A technology able to make a significant breakthrough in the cost-effectiveness of using LEDs and thereby accelerate their adoption will have a major environmental and financial impact," concludes Sophie Paturle, partner at cleantech specialist Demeter Partners.



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AMEC sets sights on GaN lighting

As MOCVD tool makers hang on for the LED upturn, an unexpected entrant from China is hoping to muscle in on the market share. Compound Semiconductor looks at AMEC's master-plan.

THIS MARCH, semiconductor equipment manufacturer, AMEC, launched its multi-reactor MOCVD cluster tool. At a time when equipment sales from Western mainstream suppliers, Veeco and Aixtron, have stalled on the back of the sluggish LED market, such a move could spell business suicide. Zhiyou Du, senior vice president of AMEC, thinks not.

"Even though we have a recession right now and the LED market it low, we strongly believe the market will pick up by next year," he says. "As a newcomer, this is the best time to enter the market. The customer is under less pressure to produce and has time to evaluate the tool."

"[The downturn] gives us about a year to qualify the tool with the customer and have our tool ready for the upturn," he adds. So ready or not, what exactly is AMEC is offering? Set-up in 2004, based in Shanghai and widely regarded as China's most successful chip-making equipment supplier, the company's main business line to date has been dielectric etch tools for semiconductor manufacturers.

Raising hundreds of millions of dollars in funds from the likes of Goldman Sachs, Qualcomm and Samsung Ventures, AMEC has released etch tool after etch tool, all of which have been steadily adopted by Asia-based chip makers. Now, the business has set its sights on the solid state lighting market and introduced "Prismo D-Blue", a MOCVD tool for high-volume production of GaN-based layer structures.

As Du explains, the tool is based on a four-reactor cluster architecture reducing its footprint by at least 30 percent relative to competitors' single-reactor tools. The four reactors can be controlled independently, with each processing up to 54 2-inch wafers depending on the batch configuration.

2-inch wafer trials have demonstrated impressive thickness uniformities; 0.4 percent wafer-to-wafer uniformity and 1 percent within-wafer uniformity. And moving to larger wafer sizes could be relatively easy.

"We have some uniformity issues right now, but in general the hardware of the system will be the same, it will just require a little bit of process tuning to get the uniformity right," says Du.

AMEC is sticking with GaN layers, and doesn't intend to develop tools for arsenides and phosphides. And crucially for the relatively new China-based LED manufacturers, the team has focused on ease-of-use. While the chamber of a competitor's tool has to be opened and the shower head cleaned after every batch run, AMEC's tool doesn't.

"Operators just don't want to do this," says Du. "The industry is getting more automated and demanding more consistency." And as Du adds, the software has been designed using semiconductor industry standards creating a 'very user-friendly' interface. "This is a very stable, repeatable and reliable tool that customers can use," he says.

From dielectric etch to MOCVD tools: AMEC hopes to compete with the likes of Veeco and Aixtron with its Prismo D-Blue

The company will first focus on the short-term opportunities in China and then the rest of the Asian market, with Europe and the US coming later. Du is certain LED makers will be ready to invest come 2014, saying: "Already we have seen signs from first tier fabs in Taiwan... we are more optimistic than we were at the beginning of the year."

So should Veeco and Aixtron worry yet? Probably not. As IMS Research analyst, Alice Tao, points out, the big two currently hold more than 90 percent MOCVD market share and are the only tool suppliers recording multiple sales over consecutive quarters. But looking to the future, she believes AMEC and other Chinese competitors may be able to seize several opportunities.

As part of its "Twelfth Five Year Plan" running from 2010 to 2015, the Chinese government identified the large-scale adoption of MOCVD tools as a priority; subsidies to domestic suppliers may return.

China has the largest demand for these tools; overcapacity still exists but as the market picks up, replacements from China-based tool makers may be favoured. And Chinese tools may be cheaper.

Tao cites some Chinese equipment suppliers as saying home-grown tools could be up to 40 percent cheaper but questions running costs. Meanwhile, AMEC expects overall cost-of-ownership of its product to be around 20 percent lower than 'industry-leading' tools.

Still, the company has several milestones to reach before it can begin to rival the industry heavy weights. Yield figures are not yet available; as Du says: "We're not running at production levels yet... but will have numbers in a month or so."

And results from 4-inch wafer trials, and beyond, have yet to surface. Again, Du says his team has achieved pretty good results, but is working on tuning the process. But as Tao told *Compound Semiconductor*: "I've talked to AMEC and they seem very confident. They are successful in the semiconductor industry, so it's possible that they might be able to compete with Aixtron or Veeco in the near future."

Indeed, the tool is currently available for beta evaluation at customer's LED production lines. As Tao concludes: "We still need to hear from the real users about the performance of these new tools and this make take a longer time."

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Hybrid silicon prepares to displace InP photonic chips

Will hybrid silicon be the platform of choice for complex photonic integrated circuits? Compound Semiconductor talks to Martijn Heck from the University of California, Santa Barbara, to find out more.

IN 2006, RESEARCHERS AT THE UNIVERSITY OF CALIFORNIA, Santa Barbara, and Intel unveiled the world's first electrically pumped hybrid silicon laser. Taking advantage of the light-emitting properties of III-V semiconductors as well as mature CMOS processes to fabricate lasers on a silicon wafer, the device unlocked the door to cheap, mass-produced silicon optical devices.

Fast forward seven years and many believe the stage is now well and truly set for a hybrid silicon photonic revolution. Myriad hybrid devices – from laser sources and optical amplifiers to high-speed modulators, waveguides and polarisation components – have been developed, forming the building blocks of photonic integrated circuits (PICs). UCSB has developed tapered mode converters to integrate hybrid silicon components with passive silicon-on-insulator substrates and used quantum well intermixing and die-bonding to

combine different bandgap components, and devices with different III-V epitaxial stacks.

Across the industry, significant hybrid integrated circuits include highly integrated transmitters, optical phase arrays and optical packet switches. And headline news covers Intel's 50 Gbit/s silicon link, Luxtera's 'millionth' chip and imec fabricating components on 300 mm silicon wafers. With these and other key players, from IBM to UCSB spin-off, Aurrion, hurrying to light up the silicon chip, Martijn Heck from the optoelectronics research groups at UCSB believes today's breakthroughs are just the beginning.

"The promise [of integrating these components] has always been there, but we have now increased the yield while specifically looking at performance and processing," he says. "The cool thing is we can now tie together the components and make these high-performance, high functionality photonic integrated circuits." This breathtaking rate of progress cannot fail to impress, but InP PICs still very much have the edge. Infinera is currently shipping optical network platforms built using 500 Gbit/s PICs, and recently demonstrated a 10 Tbit/s PIC. But could this soon change?

Heck and colleagues recently plotted a chart, showing the development of InP and hybrid silicon chip complexity, measured as the number of components per chip. Without a doubt, InP-based monolithic integration has increased in complexity exponentially over the past two decades, but according to the researchers, hybrid silicon PICs are catching up, and fast. Heck believes three key drivers are responsible for the technology's speedy transformation.

"First, we are building on mature III-V technology; we're taking existing knowledge and putting it on a silicon substrate," he says. "For example we can now fabricate 70 GHz modulators, and faster... this shows what a lot of progress we have made with the components." Secondly, according to Heck, hybrid-silicon PICs also make use of the mature CMOS fabrication infrastructure for at least part of the process flow. And thirdly, he adds: "Industry adoption has been very quick. Intel, HP and more are working on this and there is a very strong effort in Europe. People recognise the potential for this technology."

And while the gap between hybrid silicon and InP remains large – tens of components can be integrated on a silicon PIC while hundreds are squeezed onto the InP equivalent – the forthcoming data deluge could drive change. Future terabit-per-second datacom and interconnect applications will demand large volumes of highly integrated PICs. And hybrid silicon with its 300 mm silicon substrates and CMOS-compatible fabrication, offers far better economics of scale than the InP-based PIC. Heck is confident future datacoms and telecoms applications will drive integration of hybrid silicon photonics, and recalls a recent roundtable event, led by UCSB's Institute of Energy Efficiency, that looked at how data centres of tomorrow will cope with data demands.

"All the hot-shots from the main companies [Intel, Cisco, Hewlett Packard and AMD to name but a few] were there and number one on everyone's list was photonics integration," he says. "In terms of integration, we all know this is going to scale up. The steps are being taken by Intel and other companies... yes this is slightly speculative, but common sense tells us it will happen."

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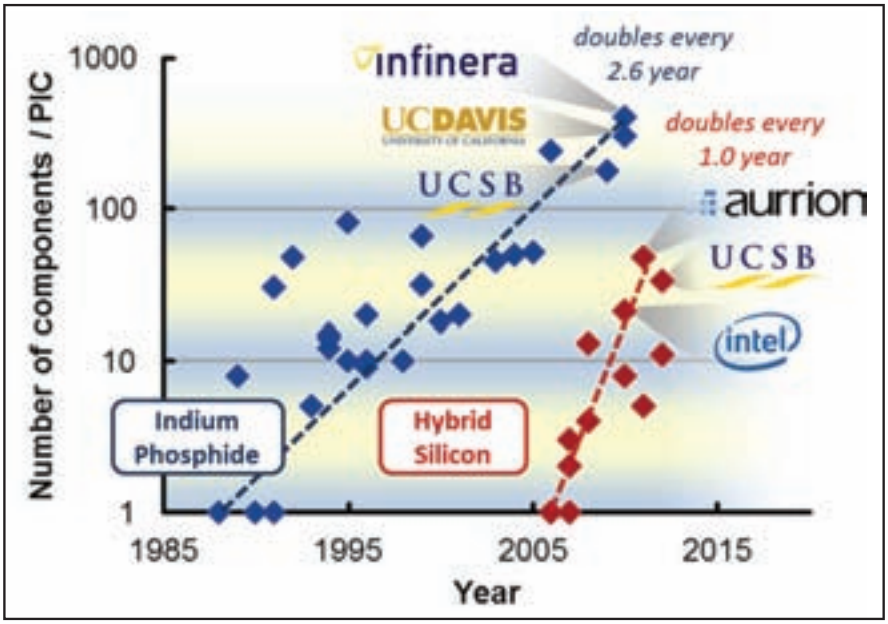

Development of chip complexity measured as the number of components per chip [credit: MK Smit, JJGM. van der Tol, and MT Hill, "Moore's law in photonics," Laser Photon. **6** 1, 2012 and MJR Heck ***et al***; "Hybrid Silicon Photonic Integrated Circuit Technology" JSTQE]

Lower cost LED lighting

Will Cree's $10 LED light bulb end America's century-long incandescent love affair asks Compound Semiconductor.

Cree's 'Filament Tower' mimics the filament of an incandescent light bulb

AS INDUSTRY ANTICIPATES AN LED market upturn, Cree has just unveiled a new line of lower-priced, incandescent look-alike bulbs that could speed the recovery. Costing from $10, coming with a ten year guarantee and offering a similar light output to the much-loved incandescent – but rated to 25,000, not 1000 hours – the bulbs have been developed specifically to kick-start sluggish domestic lighting markets across the US.

As Cree's vice president of corporate marketing, Mike Watson, told *Compound Semiconductor*: "We didn't think this segment was moving fast enough so we're giving consumers a reason to switch to LED lighting. They love the shape and the light that comes out of the incandescent so we've given them a bulb that they are used to, at a price point they will try."

And the feedback is good. Described in the *MIT Technology Review* as "the LED bulb Edison would love" and reported by many to "look like and light like" an incandescent, this is a bulb that the likes of Philips Lighting and GE will find difficult to ignore. The new line of LED bulbs includes three models; a warm white 60 W-equivalent 9.5 W bulb priced at $ 12.97, a daylight 60 W-equivalent, 9 W bulb at $ 13.97, and a warm white 40 W-equivalent, 6 W bulb at $ 9.97. Each has a colour rendering index of at least 80 with both warm white versions emitting a 2700K pleasant warm light and the daylight bulb a cooler-looking 5000K light.

Meanwhile, the Philips Lighting 60 W-equivalent incandescent copy cat, delivers a cooler 3000K at 10 W for $14.97, while the GE Lighting equivalent rings in at around $ 45. All bulbs promise a lifetime of around 25,000 hours, a long-term guarantee, but only the Cree bulb hits that magic $10 figure. So how does the LED heavyweight do it? A 40 W bulb comprises ten of Cree's phosphor-converted high voltage XLamp XT-E LEDs with the 60 W version containing twenty of the same. Phosphor is applied directly in the LED package to produce white light. Pairs of LEDs are mounted around the lamp's heatsink with Cree calling the entire vertical structure the Filament Tower.

"The LEDs are arranged in a parallel configuration to get as close as possible to the line voltage of the power supply," says Watson. "We can reduce the component count on the driver, making it simpler and lighter, and we need less metal, helping us to replicate the look of an incandescent bulb."

Indeed, Watson is keen to emphasise the simplicity of its latest bulb. "We've designed this 100 percent, and sourced the necessary components," he says. "Take it apart and you'll see how simple and elegant it really is. We needed something that could fit into this form factor and give you the look of incandescent light, at a low enough cost."

Watson asserts 'entire system' breakthroughs – from the LED and power supply to optics and design – have been crucial to cutting costs but also attributes the $10 figure to the company's structure. "We're vertically integrated and can adjust many variables at the same time and better than if we were using the traditional supply chain," he says. Vertical integration or not, many industry sources believe Cree is onto something. Pars Mukish, analyst at Yole Développement, believes the bulb will serve its purpose and trigger greater consumer adoption in the US domestic lighting market.

"Today's main issue with LED lighting for residential applications is the upfront cost," he says. "The incandescent costs less than a dollar, the compact fluorescent lamp costs between $3 and $5 while the LED lamp, before this, was between $15 and $40, depending on geography and rebates offered."
But of course the Cree bulb changes this. And as Mukish adds: " In the previous era of LEDs, it was all about increasing the lumen per watt. Now it is all about increasing the lumen per dollar... we think [Cree has] a good strategy as the potential volume triggered by residential lighting will be a virtuous circle for the company to continue decreasing costs." Indeed, question Watson whether the bulb could match the efficiency and quality of past winners of the US Department of Energy's L Prize competition and he bluntly says: "The L prize is fun, and industry rewards are fun, but the prize that Cree wants is consumer adoption."

"The bulb is designed to meet Energy Star requirements but has also been designed to be affordable with or without that. It can pay for itself in about a year... so without any rebate or government regulation we have made the maths work," he adds. "Anything else we do on that [the efficiency] side will now just make this even sweeter."

So while the bulb is currently available in Home Depot stores across the US, what about the rest of the world? It will have to wait. Watson believes the greatest demand currently lies in the US, adding:"Europe uses a lot of recessed track lighting whereas the US market already has a very large installed base of A lamps."

Still Cree's US focus looks to be working; the release of the products saw Cree's shares rise 13 percent to the highest level in two years. We have yet to see if US consumers will snap up a $10 LED lamp, but at the very least, Cree has brought affordable LED lighting closer to home.

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The Qualcomm 4G radio chip: Hit or hype?

Qualcomm's new radio chipset may take us closer to a global 4G phone, but does it really signal an end to GaAs power amps in handsets?

WHEN QUALCOMM unveiled its CMOS-based front end module, shares of compound semiconductor wireless chip vendors slumped.RFMD's nose-dived by more than 14 percent, Skyworks' dropped 13 percent, and TriQuint's dipped by around 7 percent. Some analysts cut RF vendor ratings, describing Qualcomm's release as a 'bombshell', while further down the supply chain the shares of UK-based III-V wafer maker, IQE, fell more than 13 percent in a day.

Now normality is returning, with shares of some industry players edging up. SkyWorks is busy showcasing its front-end platform – boasting take-up from myriad OEMs – while RFMD has unveiled new power amplifiers and transmit modules. So was Qualcomm's latest offering such a bombshell after all? Described as the first, single global 4G LTE design for mobile devices, Qualcomm hopes its "RF360" will end roaming problems that see travellers all-to-quickly bumped down to a 3G network. 4G LTE is the fastest commercially available wireless data standard but fragmentation between the world's LTE-supported 40 frequencies means it's not universal across the US and Europe. But despite the hope, many analysts still question when this will take place. The new RF front-end is slated to reach handsets later this year, and while the chipset could make 4G phones compatible throughout the US and Europe, compatibility across networks would be a problem, as operators haven't yet confirmed 4G roaming agreements.

Operator issues aside, the knee-jerk reaction of many has been that Qualcomm will not initially target the high-end markets dominated by compound semiconductor power amplifier heavyweights. Research analyst JoAnne Feeney from US-based Longbow Research has stated that potential technology shortcomings – relative to GaAs power amplifiers – will see the chipset adopted in lower-end smartphones.

Likewise, Raymond James analyst, Tavis McCourt, highlighted uncertain performance, predicting the solution would first penetrate Chinese markets. Indeed, in a recent stockholder conference, Qualcomm chief executive Paul Jacobs said: "If we are focusing on China, it's been a great market for us... It's the number one smartphone country in the world, 200 million smartphones were shipped in China in 2012 with a growth of 132 percent year-over-year."

Asif Anwar, analyst at Strategic Technologies, US, has a different take. "My initial reaction was, yes, Qualcomm is going into the high-volume, low-end Chinese market with this," he says. "But then the company also talks about proprietary packaging giving a 50 percent reduction in board, this will be more expensive...The smartphone market is moving into the mainstream, and you're going to need a combination of performance and cost."

Anwar, like many, is also adamant GaAs still has the performance edge despite rapid progress from CMOS competitors. Qualcomm has worked hard on its envelope-tracking (ET) technology to reduce power consumption by up to 30 percent, and nudge the efficiency of its power amplifiers closer to that of GaAs.

At the same time, Nujira has revealed "breakthrough" test results from a prototype CMOS power amplifier coupled with its envelope-tracking power modulators. Chief executive, Tim Haynes asserts: "The combination of CMOS PAs and Nujira patented ET architectures could ultimately signal the death of the GaAs industry for handset applications."

However, RFMD has now released new ET power management products, with president Eric Creviston claiming to be "enthusiastic about the deployment of ET-based solutions". As Anwar highlights: "Envelope tracking isn't solely confined to CMOS PAs. RFMD has just announced ET for its PAs as well as GaAs PAs designed to work with Qualcomm's ET. Other PA suppliers will follow with PAs designed for ET."

Qualcomm also highlights how its latest front-end, when combined with its Gobi or Snapdragon baseband chip-sets, can provide a comprehensive solution that will help OEMs minimise development and design costs. As Jacobs highlighted in a recent stockholder conference, Nokia Lumia, Galaxy S3, HTC One and Sony XperiaZ are all built on Snapdragon chipsets. But do high-end market players want a complete base-band and front-end solution?

"If you open up an Apple or a Samsung phone you will see [components from] TriQuint, RFMD, Avago, Skyworks and Anadigics, they are all there," says Anwar. "So the handset OEMs are quite comfortable with mixing and matching components to optimise performance at a competitive cost, and differentiate their products. This isn't to say the Qualcomm front-end won't have an impact, of course it will, but we're not going to see Qualcomm take away GaAs market share straight away."

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UV LEDs: Will substrates slow growth?

As long wavelength ultraviolet LEDs penetrate commercial curing markets, shorter wavelength counterparts prepare to take on water sanitation, wireless handset disinfection and more. But will substrate and epitaxy issues stymie progress?

IN MARCH THIS YEAR, France-based analyst firm Yole Développement forecast the ultraviolet LED market would mushroom from today's $45 million to nearly $270 million in the next four years.

Growth stems from UV curing system makers replacing incumbent mercury vapour lamps with smaller and longer-lasting long-wavelength UV-A LEDs. But throw in wild-card applications using shorter wavelength UV-B and UV-C LEDs – nail gel curing, miniature counterfeit money detectors and more – and the UV LED market could stretch further.

"We estimate that if new UV LED applications continue emerging, the associated business could represent nearly $30 million by 2017, increasing the overall UV LED market size to nearly $300 million," says Mukish.

And right now, the industry looks buoyant. For the UV-A end of the market, new competition from China, Japan and Taiwan is stirring the likes of Nichia, Japan, SemiLEDs, US, and Seoul Semiconductor, Korea, prompting lower prices and a wider adoption of the technology.

Crucially, the performance of these UV-A LEDs, emitting at 400 nm to 315 nm, is now sufficient to rival incumbent technologies, largely thanks to relatively straight-forward manufacturing. These devices are fabricated by growing InGaN-based epilayers on sapphire substrates, with the same MOCVD techniques used in visible LED markets.

"We now think several players from the visible LED industry could move into this UV market, as over-capacity has impacted their margins," adds Mukish. "This is not a huge market but the margins are higher."

However, the shorter wavelength market for UV-B LEDs emitting at 315 nm to 280 nm and UV-C LEDs emitting at

280 nm to 100 nm is a different breed of animal. Fewer market players exist; US-based Sensor Electronic Technology Inc (SETi) leads the way with Crystal IS and HexaTech, both based in the US, emerging from development phases and eager to commercialise.

SETi opened a high volume manufacturing plant, last year and recently unveiled UV-B and UV-C LEDs targeting forensic analysis, water disinfection and other applications. Meanwhile, Crystal IS – acquired by Japanese industrial giant Asahi Kasei last year – and HexaTech have both claimed record performances for UV-C LEDs targeting water and surface disinfection applications.

But despite the progress, crystal growth and epitaxy issues still need to be ironed out before shorter wavelength UV LEDs can achieve true commercial success. Devices can be manufactured by either depositing AlN layers onto a sapphire substrate or a bulk AlN wafer. And herein lie the problems.

For starters, growing bulk AlN crystals isn't easy. Crystal IS, HexaTech, Nitride Solutions, US, and Germany-based company CrystAL-N have made great strides in growing the substrates, yielding high performance LEDs, but still 2-inch wafers are not widely available and remain much more expensive than sapphire substrates.
"The performance of LEDs grown on a AlN substrate is better but the supply chain for bulk AlN substrates is not so evolved. Only two to three companies can provide these substrates on the open market and so costs haven't decreased," says Mukish.

"This was also the case for GaN bulk substrates used in visible LEDs, and in the end LED manufacturers chose sapphire substrates," he adds. "[Future UV market developments] depend on how suppliers of AlN substrates develop the size of substrates and also reduce costs."

Substrate issues aside, these UV LED players must also solve epitaxy problems. Issues relating to, for example, strain and doping need to be fully tackled, and as UV-A LED manufacturers race ahead with well-used MOCVD techniques, deeper UV LED players are left to develop new methods or grapple with less established deposition technologies. As Mukish points out: "Many LED manufacturers use HVPE to fabricate shorter wavelength chips, and this [deposition method] is not as advanced."

Still progress has been made. HexaTech joined forces with Japan-based HVPE developer, Tokuyama, last year, producing UV-C LEDs described as having record-setting reliability and lifetimes. And SETi has unveiled deeper AlN-on sapphire UV LEDs grown via migration enhanced MOCVD and migration enhanced lateral epitaxial overgrowth.

"The UV LED market is not so big, which means there are not so many players to collaborate and really develop UV-B and UV-C chips," says Mukish. "So we have seen Crystal IS and Hexa-Tech vertically integrate the supply chain to provide their own device. These companies are busy working on these issues."

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SiC infiltrates inverter markets

As photovoltaic inverter manufacturers adopt SiC MOSFETs, when will other industries move towards wide bandgap devices?

AS THE POWER ELECTRONICS market embraces a buoyant decade, the future for wide bandgap devices looks bright. SiC diodes have stormed into the photovoltaic inverter market, and the same flavour of MOSFET is now penetrating this high-end segment. This trend looks likely to continue.

Recently, market analyst Yole Développement, predicted the entire inverter market will swell from $45 billion in 2012 to $71 billion by 2020. As expected, the market segment of the moment for the SiC industry is PV inverters, but as Yole analyst Alexandre Avron highlights, unexpected opportunities have surfaced.

"Yes, we are seeing PV inverters first, but what is a little surprising is the use of SiC [devices] in light rail traction applications," he says. "There has been a real interest for the SiC MOSFET and several companies are already carrying out field tests." As Avron highlights, Alstom is testing SiC MOSFETs in its auxiliary inverters for trains. "Many more small research and development teams in major businesses, especially in Asia, are pushing for new materials," he adds. "This is a traditional, conservative market. You just don't expect rail traction to be attracted to SiC."

More predictably, Avron expects the equally conservative hybrid and electric car manufacturers to show a greater interest in SiC devices. These components can operate at much higher temperatures than silicon counterparts, removing the need for liquid cooling loops and cutting the size, weight and volume of the overall inverter system.This is quite a bonus for the performance-driven but space-constrained car manufacturer. But still these players will first scrutinise how SiC performs in the solar industry, which as Avron puts it, is providing the "field test".

"We've looked at these photovoltaic inverters and right now the architecture hasn't changed much," he says. "Manufacturers have taken out the 1200V silicon IGBTs and put in either a SiC MOSFET or JFET, and changed the input boost converter a little bit. They will now see how the [device] reacts in real-life conditions at higher volumes of production."

But change is afoot. According to Avron, new inverter architectures – that make the most of the advantages that SiC MOSFETs and JFETs can bring – are under development. "These have, for example, higher switching frequencies, and if you compare the [designs] to today's architectures, you really see how much room for improvement there is."

Avron doesn't expect the new, improved inverter architectures will surface for two to three years yet. "We know [other industries] will go for these inverters, but first inverter manufacturers need to see exactly how SiC reacts." he adds. "The MOSFET is really the heart of the inverter and if your heart isn't strong then you've wasted your money... but in two to three years, manufacturers will no longer be afraid to base a real product on the SiC MOSFET." But what about GaN – many power device manufacturers have touted progress in high power GaN diodes and transistors – yet how many products have reached the market? The long-awaited arrival of the SiC MOSFET only came after a long fanfare of announcements, and Avron is concerned GaN transistors are following the same path.

"We've seen lots of marketing about what companies are doing in-house, but still we don't have a 600 V device available," he says. "I expect there are non-disclosure agreements and the players are getting the first production batches from GaN manufacturers, but it's a little late."

Still, progress is underway. For example, California-based Transphorm qualified its 600V HEMT last year and recently revealed a 600V GaN module for GaN-based high power PV converters. And Avron reckons industry will adopt these and future GaN devices.
"We think it will take a little bit of time... but SiC should be used in very high voltages and we could then see GaN used where SiC is now, PV inverters, electric cars and so on," he says. "We are seeing different positioning for GaN and SiC, and more people are accepting that there is no full competition between the two [technologies]."

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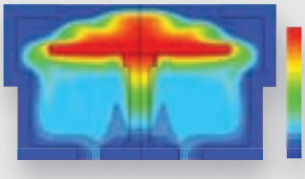

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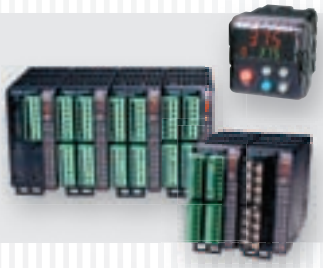

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Graphene-on-SiC heads from lab to fab

To fulfil the tremendous potential of graphene, high-quality material must be shipped in significant volumes. One supplier looking to do just that is Graphensic, which has developed graphene-on SiC products for making structures for metrology, high-speed transistors and biosensors. Company founders Rositza Yakimova, Mikael Syväjärvi, and Tihomir Iakimov detail their progress.

Cubic SiC used by Graphenesic

IT MAY SMACK OF HYPE to refer to graphene as the wonder material, but it is an accolade that is richly deserved: This allotrope of carbon, which is based on atomic sheets, is destined to make massive improvements in numerous areas, including the construction of lighter, stronger airplanes, the manufacture of ultra-fast batteries and the production of new or better electronics.

The pioneers of this material are Andre Geim and Konstantin Novoselov from the University of Manchester, UK, who reported their ground-breaking discovery of this new form of carbon in 2004. Since then they have shot to fame, netting a Nobel Prize in 2010 for their efforts. Following their discovery, research into graphene has mushroomed, with commercial interest in this material taking off. However, graphene is never going to fulfil its potential as a wonder material that can serve mankind in many ways unless it can be manufactured by industrial processes in high volumes.

At Graphensic AB, a spin-off of Linköping University, Sweden, we are one of a handful of companies addressing this. We produce high-quality films of graphene on SiC substrates with a unique manufacturing method involving high-temperature processing.

Graphensic's origins

For us, forming our company was a natural evolution. When we had been working at Linköping University, we received an increasing number of requests for both material and research collaborations. These requests eventually exceeded those we could manage within unfinanced research collaborations, and at that point in time it was an obvious step to form a company. We did this in late 2011. We manufacture materials by direct sales and through development projects aiming to build up the company through customer sales.

Development and production of products utilizing graphene demands a steady, reliable supply of this material. Several companies are meeting this need, and one of the key differences between them is that they are producing different types of graphene on different foundations. The graphene that is manufactured can be a single layer of carbon atoms (monolayer graphene), or two or a few layers of this element (bilayer and multilayer graphene, respectively). It can be produced as flakes, or on a substrate, such as a metal or SiC. Graphensic is one of the first companies in the world specialized in producing high quality graphene on SiC.

Flakes can be made by various methods. There is the scotch tape method, which was used by the Nobel Prize winners to make their first samples, and there are also chemical methods. In Europe, flakes are used by the UK firm Graphene Industries. These processes are attractive from a quality perspective, but the graphene that is formed is small, preventing it from being used for various electronic applications.

Larger sizes are possible by producing graphene on a metal or SiC. Graphenea in Spain provides this kind of product, which is used to transfer the graphene film to the active region of a device, such as a flexible polymer or silicon. Using graphene in this manner, it is preferable to use a metal rather than SiC as the substrate, due to lower substrate costs.

So what is the benefit of SiC? It's not for transferring graphene to another material, because that transfer process is challenging from technical point of view, due to the close bonding to the substrate. And transfer is costly, due expenses associated with chemicals and facilities. But graphene-on-SiC is best suited to applications where the SiC substrate forms either an active part of a device, or acts as a suitable template. This is possible, because SiC offers biocompatibility and chemical inertness.

The key difference between using a metal and SiC as the substrate is that a metal is always conductive, while SiC can be semi-insulating or doped. This equips graphene-on-SiC with an advantage for various electronic applications, and allows this to target markets that are impenetrable by either flakes of graphene and SiC-on-metals products. There are also markets where all three classes of product can compete. In those cases, processing and cost issues will determine which format is most successful.

Substrates and processes

We produce our graphene films on 6H and 4H-SiC substrates. Although these are commercially available in diameters of up to 150 mm, there are some issues regarding substrate defects and the large bandgap to consider. Due to the latter, we are also interested in the development of the cubic form of SiC (3C-SiC) as a foundation for graphene.

In our process for forming graphene, the SiC substrate has a dual role, acting both as a precursor and a substrate for epitaxy. When the substrate is heated to 1500-1600 °C in a gas ambient, SiC vapour species start to leave the surface, which rearranges itself to form a buffer layer. Graphene then forms on top.

The nature of the graphene formed by this approach is strongly influenced by the processing temperature. When SiC species vaporize, the ratio of silicon-to-carbon atoms varies, depending on the conditions. Silicon has the higher vapour pressure, so

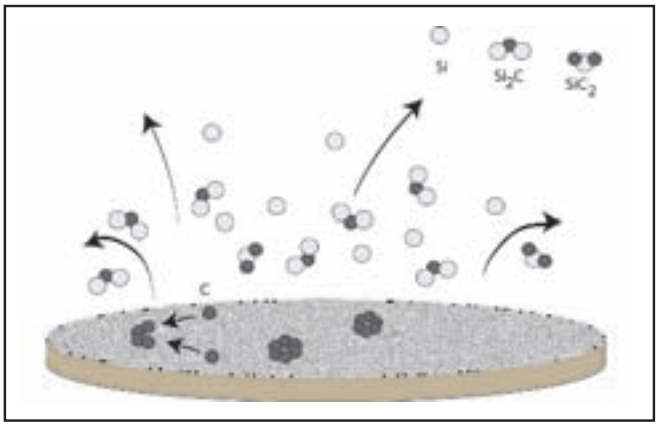
Experience in SiC growth system opens the potential of large area growth of graphene

the ratio of silicon to carbon is large at a lower temperature, and decreases with increasing temperature to approach an ideal ratio of 1. Given this, it is favourable to apply a high temperature, such as 2000 °C, to liberate similar populations of silicon and carbon atoms.

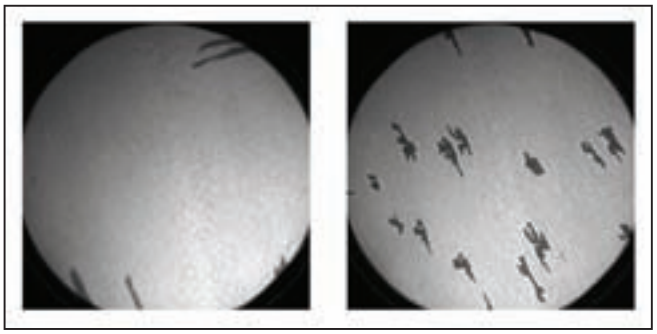
The process yields high quality monolayer graphene over a large area of a wafer. This success partly results from our strong background in SiC research at Linköping University. At this institution, SiC growth has been developed for almost 20 years. Methods that have been pioneered range from liquid phase epitaxy – which was initiated by a programme to make the world's first SiC growth in microgravity using the sounding rocket MASER7 at Esrange in northern Sweden – to various sublimation growth methods.

Substrate issues

As stated previously, commercially available, hexagonal forms of SiC are mainly used for the formation of graphene. This provides interesting features of the crystal and materials behaviour. That's because these classes of SiC are polar, with opposing sides terminated by either silicon or carbon atoms. These two surfaces have a substantial difference in the surface free energy, and this accounts for the far greater challenge in preparing graphene on the carbon face than the silicon face.



Graphene formation on a SiC wafer



Low-energy electron microscopy images of 3C (left) and 6H (right) showing large domains (>50 μm) and dominating monolayer graphene with dark areas of bilayer graphene. Images: Alexei Zakharov, MaxLab

Another challenge stems from the not perfect orientation to a low index surface. The slight off-axis orientations of the SiC substrates create atomic steps, and when this wafer is heated, the surface rearranges and undergoes a step-bunching process: Initial small steps turn into larger ones, with larger terraces and a step edge. Often monolayer graphene is formed on the terrace, and bilayer graphene on the step edges.

Surface rearrangement is a natural process in SiC, with the first atomic layers rearranging to a buffer layer. In graphene, this is believed to induce doping, which is not wanted in some applications. To prevent this, some researchers are trying to expose graphene on SiC to certain elements that can penetrate beneath the graphene and change the buffer layer into a graphene layer. Success in this endeavour creates monolayer or bilayer graphene without a buffer layer.

New standards

Many researchers around the world are investigating the properties of monolayer, bilayer, and multilayer graphene on silicon and carbon faces. One highlight of these efforts is associated with the development of monolayer graphene with a buffer layer, which has shown outstanding performance in metrology. We have found that our graphene on SiC provides a resistance standard in quantum Hall measurements that is several orders of magnitude better than the current one based on GaAs (quantum Hall measurements relates Planck's constant, ***h***, to the electron charge, ***e***). This could aid the International System of Units, providing quantum units of mass and current based on these fundamental constants of nature.

Another exciting opportunity for graphene-on-SiC is its use in the creation of a monolithic transistor for combining an on/off ratio or more than 10^4 with the absence of damping at megahertz frequencies. Fabrication, in its most simple form, requires just a single lithography step to build transistors, diodes, resistors and eventually integrated circuits, without the need of metallic interconnects. One hurdle to the realization of such circuits is the lack of a bandgap for graphene. However, this can be addressed by turning to ribbons of graphene, which have a bandgap of 0.5 eV and can be produced by making forced topographical changes on SiC. Note that it is not possible to modify a metal substrate so that it yields graphene ribbons.

Yet another area where graphene-on-SiC could make a commercial impact is in the field of biosensors. Electrical properties of graphene channels in transistors are influenced by minor perturbations, such as molecules on the surface. This high degree of sensitivity stems from the combination of a high surface-to-volume ratio and tuneable electron transport properties, which result from quantum confinement effects. The upshot of this is that these devices have the potential to detect single molecules.

Biosensor operation is based on the use of a target disease biomarker. This provides a change in the surface charge density, which is detected as an electrical signal. SiC and graphene are very promising materials in this field, because they exhibit excellent biocompatibility with *in vivo* and *in vitro* studies, and they show no cytotoxicity responses. Commercial opportunities include the development of miniaturised systems for the detection of disease biomarkers for use in the early diagnosis and monitoring of diseases.

Development of graphene on SiC is on going, and we are keen to pursue growth of the cubic form of this wide bandgap material. It is rare in bulk-like form, but it appears that this platform could create structures that are free from the buffer layer. Our research group has developed sublimation methods for growth of 3C(111) and 3C(100) on hexagonal SiC substrates at a high growth rate of up to 1 mm/hr. Traditionally this material is grown on silicon, but this causes stress by a high thermal and lattice mismatch. Our aim is to be able to provide substrates of 3C using this approach.

Although all forms of SiC are not cheap platforms for graphene, we are convinced that this class of material system has great commercial opportunity. We are shipping material to customers from all around the world, and as we watch the number of publications reporting advances in graphene-on-SiC rise, we are confident that this will spur the establishment of markets where this form of graphene dominates. Commercial exploitation of this material is yet to begin, but given its wonderful set of attributes, what it can realise is only limited by our imaginations.

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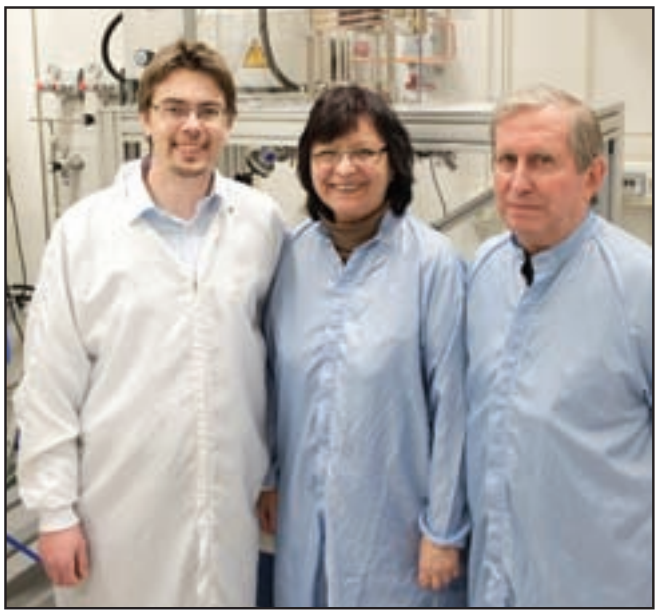

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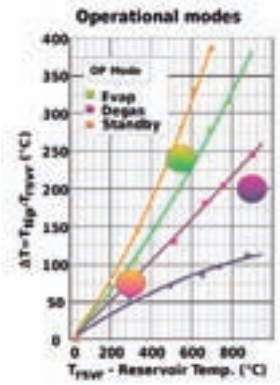

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Strategies for enhancing photovoltaic performance

There are many options for improving the performance of III-V solar cells, including inserting quantum wells and dots to extend spectral coverage and adding nanoparticles and diffraction gratings to boost light trapping. Insights into all these approaches are outlined by Sudha Mokkapati, Samuel Turner, Haofeng Lu, Lan Fu, Hark Hoe Tan and Chennupati Jagadish from The Australian National University.

EFFICIENCY IS THE KEY metric for solar cells. Increasing this ups the energy produced by the cell, and in turn cuts generation costs and trims the footprint of the cell required to deliver a given output.

One option for enhancing the performance of a conventional solar cell is to modify its design by inserting structures that stretch the spectral absorption to longer wavelengths. Adding quantum wells and dots can realize this, with greater spectral absorption increasing short-circuit current densities that could ultimately boost the overall efficiency of the solar cell. Gains in current resulting from the incorporation of wells or dots also open up new opportunities for bandgap engineering, allowing better current matching between different sub-cells of a tandem solar cell. For example, in a Ge-InGaAs-InGaP tandem solar cell, inserting InGaAs quantum wells or quantum dots into the InGaAs middle sub-cell transfers current from the current-overproducing bottom sub-cell to the current-limiting middle sub-cell.

A handful of research groups have pursued these approaches to improving solar cell performance. For example, Keith Barnham's group at Imperial College, London, have increased the spectral response of an AlGaAs reference cell by turning to GaAs-AlGaAs quantum well solar cells, while our team at The Australian National University have enjoyed similar success by replacing a GaAs reference cell with a InGaAs-GaAs quantum dot solar cell (see Figure 1 for details of the bandstructure of these novel cells).

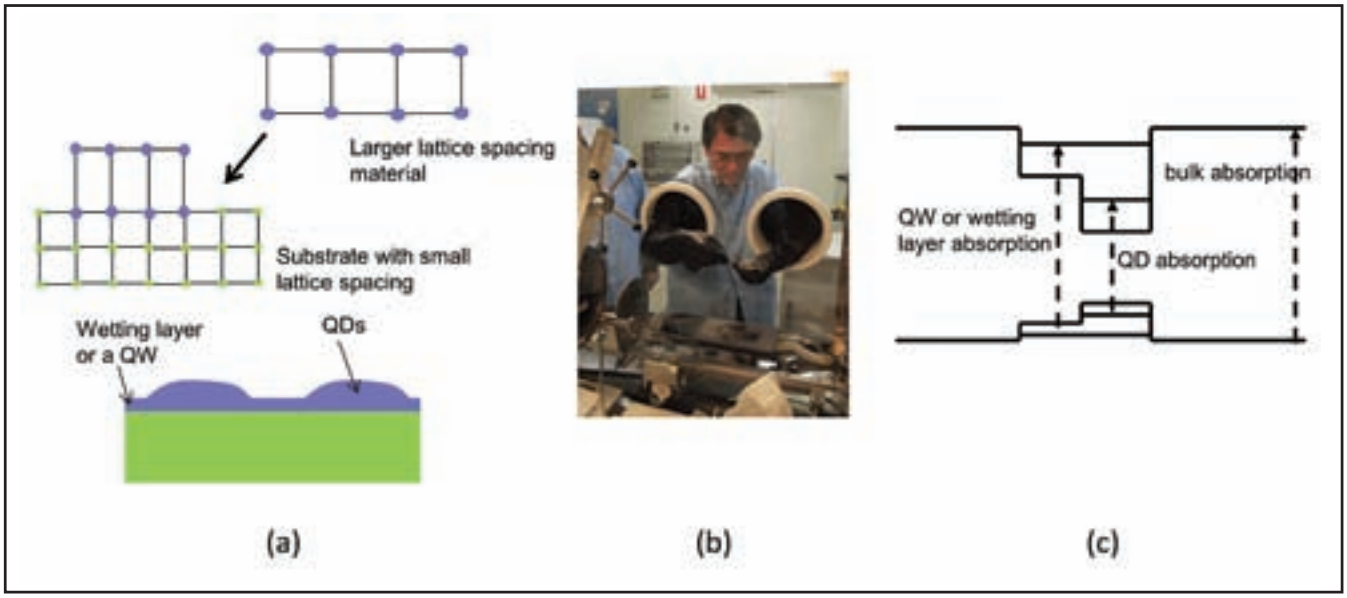

Figure 1: The formation of quantum dots in the Stranski-Krastanov growth mode (a) and the MOCVD reactor used for growing QWs/QDs (b). The relative bandgap energies of $In_xGa_{1-x}As$ quantum dot and quantum well (or wetting layer) with respect to bulk GaAs (c)

Quantum wells and dots provide confinement of electron and holes in one and three dimensions, respectively. Both are grown epitaxially by techniques such as MBE and MOCVD. The growth of wells is very well established in academia and industry, while the formation of dots is predominantly carried out in university labs.

Dots are produced by depositing a material with a larger lattice constant on a substrate with a smaller one – in our case we grow an $In_xGa_{1-x}As$ film on GaAs using a MOCVD reactor (see figure 1). Initially, the material with the larger lattice constant tries to grow in a layer-by-layer fashion, adjusting its lattice spacing to match that of the substrate (see Figure 1). This leads to a build up of strain in the structure, which creates defects when it exceeds a certain value. To prevent this from happening, the thickness of the deposited film must be kept below a certain value, which is governed by lattice mismatch.

As the growth of the deposited film continues, strain in the system increases, and beyond a certain threshold three-dimensional islands or quantum dots begin to form. That's because for this configuration, the total surface energy is lower than the strain energy for two-dimensional growth. Beneath the quantum dots, a thin two-dimensional layer, known as a wetting layer, still exists. This is essentially a thin quantum well. Formation of quantum dot heterostructures by this approach is said to employ the Stranski-Krastanov growth mode.

A severe limitation associated with both quantum wells and dots is the very small absorption volume. For example, the absorption fraction of a single 7 nm $In_{0.21}Ga_{0.79}As$ quantum well is only of the order of 1 percent beyond the bandgap of GaAs. So, to absorb a significant fraction of light beyond the band edge of GaAs, there needs to be a substantial increase in the absorption efficiency of the quantum wells and quantum dots.

One way to do this is to stack layers of quantum wells/dots on top of one another. However, the high level of strain in these quantum-confined absorbers means that when several of these layers are stacked together, excess overall strain can spawn the formation of dislocations, which act as non-radiative recombination centres that degrade device performance.

What's more, stacking too many quantum well/dot layers together may make it very challenging to extract carriers from the middle layers. Consequently, alternative approaches are needed to increase the absorption efficiency of long-wavelength light for efficient quantum well/dot solar cells.

A hike in the absorption probability is possible via a process known as light trapping - the 'folding' of light into a thin absorber layer to increase light-matter interaction times. Folding or trapping light in the absorber layer increases the optical thickness of this layer to values far beyond its physical thickness. In an absorber layer that supports only a few waveguide modes, light is trapped by coupling it to the waveguide modes. This switches its propagation direction from perpendicular to the absorber to parallel to it.

For relatively thick absorbers that support a continuum of optical modes, light is trapped by exploiting total internal reflection (see Figure 2). The strength of this approach is that light is coupled into the absorber outside of the escape cone (or at angles

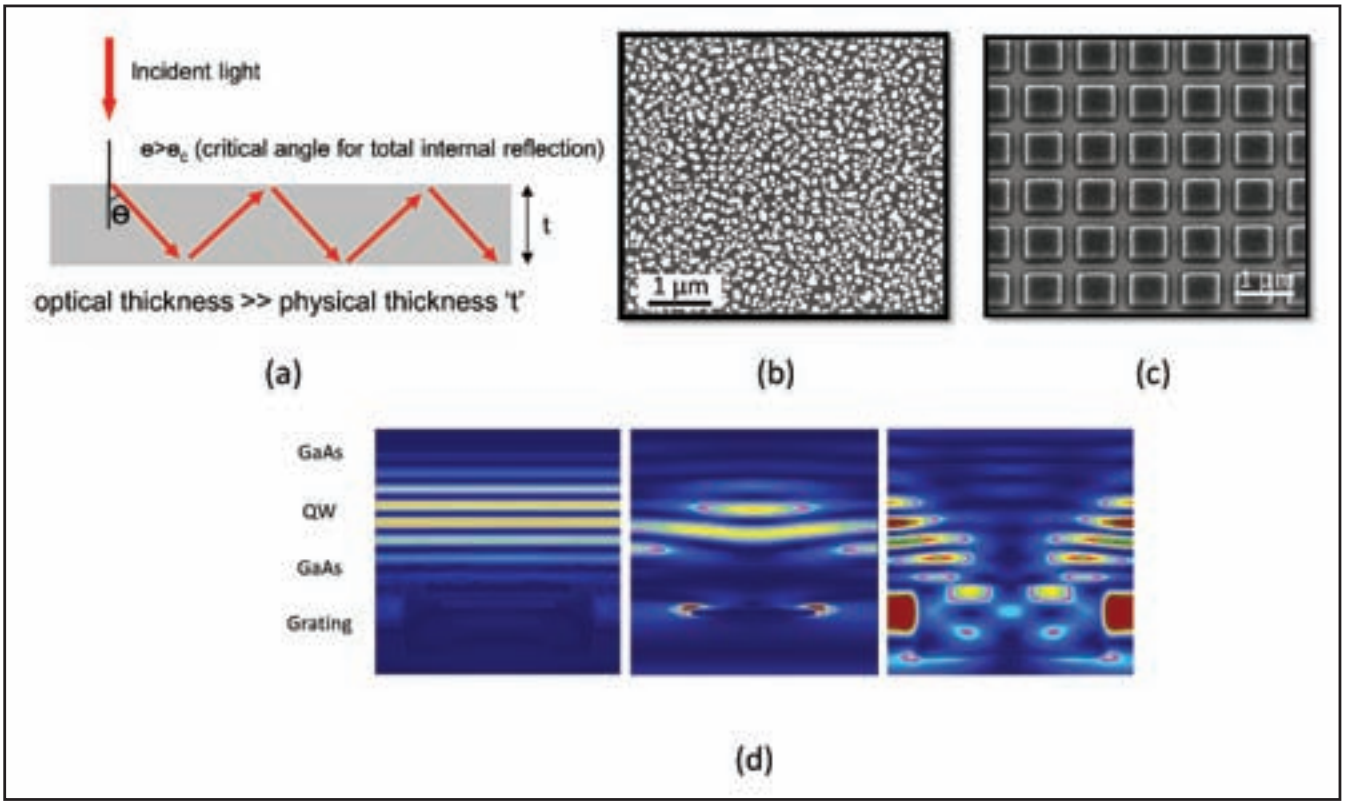

Figure 2 : Light trapping in thick solar cells by total internal reflection of weakly absorbed light (a). Scanning electron microscope images of a plasmonic nanoparticle array (b) and a diffraction grating (c) that are both fabricated on a solar cell. (d) shows how a plane wave front incident on a solar cell (left) is modified by the presence of a plasmonic nanoparticle (center) and a dielectric gratig (right) on the rear surface of the solar cell

larger than the critical angle for total internal reflection at the absorber-air interface). We work with substrate-based structures that support a continuum of optical modes and feature either quantum well or dot absorber layers. We employ two light trapping approaches to enhance the absorption efficiency of long wavelength light in our quantum well/dot solar cells: plasmonic light trapping and the addition of a diffraction grating on the surface of the solar cell.

Powerful plasmonics

Light trapping is possible using plasmonic nanoparticles – tiny metallic structures that interact with the incoming light and exhibit local oscillations in the density of their free electron gas. One consequence of this phenomenon is that incoming radiation is scatterred into the solar cell at angles outside the escape cone.

Good light trapping with plasmonic structures is possible by exceling in two areas: maximizing the scattering cross-section of the plasmonic nanoparticles, and realising a high efficiency for the coupling of scattered light into the substrate. It is vital to maximise the scattering cross-section, because this ensures that the nanoparticles interact with most of the light incident on the solar cell and randomise its direction.

Meanwhile, it is critical to achieve a high coupling efficiency of scattered light into the substrate of the solar cell, because this minimises reflection or transmission losses at each encounter between the weakly absorbed light and the plasmonic particles. It is also important to address parasitic losses, which are inherent to the resonant metallic nanostructures. We form our plasmonic nanoparticles by depositing a thin silver film on the surface of a finished solar cell and annealing it in a nitrogen atmosphere. Nanoparticle arrays result from the difference in thermal expansion between the metallic layer and the substrate (see Figure 2).

The fabrication process is relatively easy, since it does not require modification of the solar cell fabrication process and is scalable to large areas. Last year we reported an 8 percent enhancement in the efficiency of a quantum dot solar cell through the addition of plasmonic light trapping. The improvement in power predominantly came from an increase in short-circuit current density (J_{sc}) by 5.6 percent – the open-circuit voltage (V_{oc}) also went up, but just by 0.9 percent.

A good indicator of the effectiveness of a light trapping strategy is the enhancement in path length. This is defined as the ratio between the average distance travelled by weakly absorbed light in a solar cell featuring light trapping, to the distance travelled in a planar solar cell. Based on experimental results from our plasmonic quantum dot solar cell, we calculate that this path length enhancement is approximately two at a wavelength of 1000 nm. We can explain why this value is much smaller than expected from a good light trapping structure: Our solar cells are fabricated on n^+ substrates, so free carrier

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absorption (parasitic losses) in this platform limits the benefits of this light trapping structure. We expect that parasitic losses in the device can be cut, leading to an increase in the short circuit current density and the efficiency of the solar cell, by fabricating solar cells on semi-insulating substrates.

Dielectric grating gains

Another way to couple incoming light into diffraction orders outside of the escape cone in the solar cell is with wavelength-scale diffraction gratings. These periodic structures are difficult to fabricate and require a lot more process optimisation, but they do not have the parasitic losses inherent to metallic structures. The latter strength indicates that they should be better for light trapping applications in solar cells, where every available photon is valuable.

When gratings are fabricated on the surface of a solar cell, they restrict the number of optical modes in the device to which the incident light can couple. The number of diffraction modes in a material depends on the periodicity of the grating and the refractive index of the cell. Employ a very small period grating, and only the principal diffraction mode in the solar cell that lies within the escape cone is supported.

Turn to a very large period grating, and a continuum of modes can then be present in the solar cell and in air. However, a large fraction of the diffraction modes supported in the solar cell are within the escape cone and do not effectively trap light.

The sweet spot is to use wavelength-scale diffraction gratings (such as the ones shown in Figure 2), which support only the principal diffraction mode in air, plus a few higher-order diffraction modes that lie outside the escape cone in the substrate. Good light trapping is then possible, thanks to efficient coupling of incident light to these higher order modes in the substrate (see figure 2).

The key to efficient light trapping is two-fold: It involves maximising the relative number of diffraction modes outside the escape cone in the solar cell, with respect to the number of modes supported in air; and realising efficient coupling of incident light to these modes. The most efficient structures for light trapping are bi-periodic gratings with asymmetry introduced into the grating structure to satisfy these criteria.

According to our calculations, the addition of an optimised asymmetric TiO_2 grating structure at the rear of the solar cell can increase the short circuit current density of a ten-stack $In_{0.21}Ga_{0.79}As$-GaAs quantum well solar cell from 1.03 mA/cm^2 to 3.30 mA/cm^2.

A common benchmark for assessing the performance of a light trapping strategy is the theoretical concept of Lambertian light trapping or the isotropic limit. This has been developed in the context of wafer-based silicon solar cells. The best that one can do in this case is a path length enhancement of $4n^2$, (where n is the refractive index of the solar cell material), which is achieved using a Lambertian scatterer at the solar cell surface. It is possible to mimic a Lambertian surface by texturing the solar cell surface with random pyramids with feature sizes of the order of a few tens of microns.

To gauge the effectiveness of the plasmonic structures and the dielectric gratings – and compare with Lambertian light trapping – we investigate the relative short-circuit current-density enhancements (ratio of J_{sc} enhancement from a given light trapping structure to the maximum possible enhancement in J_{sc} assuming all of the incident light is absorbed in the quantum wells) from the quantum well region of a ten-stack $In_{0.21}Ga_{0.79}As$-GaAs quantum well solar cell.

At the optimum geometry, a TiO_2 dielectric grating can deliver a relative J_{sc} enhancement of 82 percent. This increase in current is much larger than the 28 percent that we obtained using plasmonic light trapping, and comparable to that of a Lambertian scatterer (95 percent). As mentioned earlier, the inferior result for the plasmonic light trapping structures is partly due to the absorption in the metal itself, which leads to very low short circuit current density enhancements compared to the dielectric structures that do not absorb the incident light.

We are now working on fabricating plasmonic solar cells on semi-insulating substrates, because this will minimize the free carrier absorption in the substrate. In addition, we are optimising the fabrication processes for wavelength-scale TiO_2 diffraction gratings, so that these light trapping strategies can then be used in thin-film III-V semiconductor solar cells, where epitaxially grown thin-film absorbers can be lifted-off from the substrate and supported on an inexpensive substrate with light trapping strategies. This approach will allow the expensive substrates to be re-used, thereby reducing material cost in solar cell manufacturing.

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Further reading

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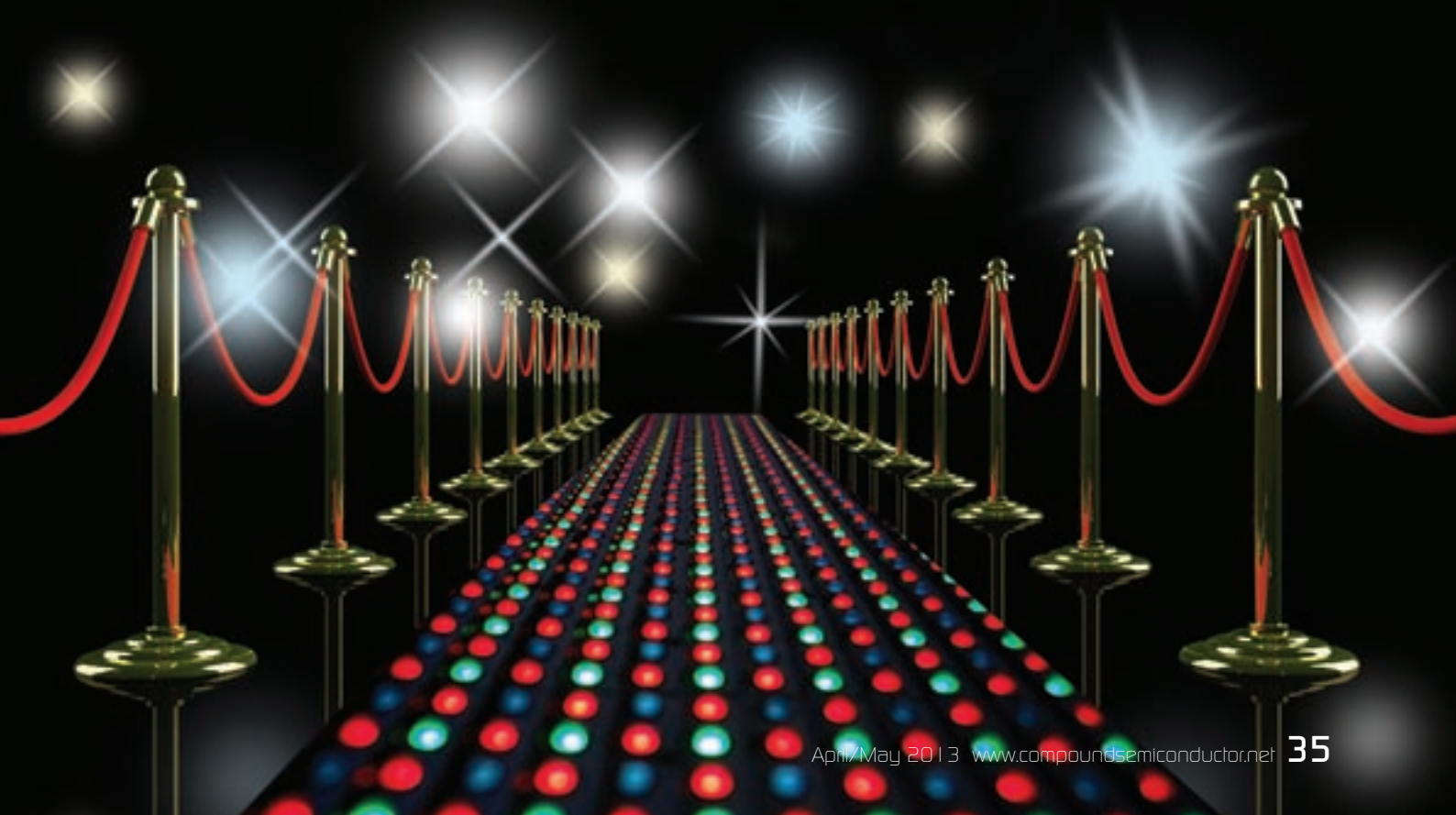

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For over a decade Temescal has been dedicated to mapping and better understanding the dynamics of the flux cloud. Through extensive testing and research we have collected hundreds of vapour cloud maps and used these maps to advance and automate the process of lift-off uniformity mask design.

What industry challenge does this address?
At the heart of every electron beam evaporation system is a unique yet repeatable vapour cloud of flux distribution. It conforms to the characteristics of radiation from a point source. However, each of these flux clouds vary based on material characteristics and a variety of other deposition process factors — like deposition power, the use of a crucible liner, crucible size and beam spot focus.

Precision lift-off coating in a conventional box coater is often inefficiently optimized for these flux clouds. The use of results in an excessive consumption of process metals. Auratus solves this problem optimizing process tooling to the vapour cloud improving efficiency and reducing waste.

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Richard Stevenson, Editor, congratulates Gregg Wallace, Managing Director

Richard Stevenson, Editor, of Compound Semiconductor commented:
"The price of gold has shot up in the last few years. However, thanks to Ferrotec, this hike in costs can by combated by improvements to deposition efficiency."

DEVICE DESIGN AND PACKAGING AWARD

Winner: **SETI inc.**

For: **III-Nitride Varactors with Capacitively-Coupled Contacts – New technology platform for RF electron**

SETI has developed novel technology platform for monolithic microwave integrated circuits using capacitively coupled contacts (C3 varactors over III-Nitride heterostructures).

Novel device type offers simple and robust fully planar alignment- and anneal-free fabrication technology. At 18 GHz the fabricated C3 microwave switches exhibit record low 0.8 dB loss and high 27.5 dB isolation.

C3 power limiters offer insertion loss in the range 0.2 – 0.7 dB and wide range of limiting powers 17 – 40 dBm. Novel C3 devices demonstrate full compatibility with III-Nitride electronics and have a great potential for high-performance MMICs.

The C3 varactor consists of two electrodes deposited on top of AlN/GaN/InN heterostructures. Conducting channels in the heterostructures with record high 2D electron gas density (up to 1.5x1013 cm-2) and high electron mobility (up to 2500 cm2)/(V-s) form metal-like conducting plates. The electrodes form capacitively-coupled contacts with 2DEG channel with low impedance at RF frequencies typically above 2 GHz.

The C3 varactor can be turned off by applying the voltage across any of its contacts exceeding the pinch-off voltage. C3 varactor does not consume significant DC bias current in addition it offers several important advantages as an RF device: (1) it has no gate so the total channel length is more than two times smaller than in HFET with the same source – gate and gate-drain spacing and hence about the same breakdown voltage (2) it has no ohmic contacts this eliminates annealing the need to align the gate and further increases the breakdown voltage due to lower edge roughness (3) it can be controlled using either positive or negative bias polarity(4) provides a built-in DC block.

What challenge does this address?

Modern RF systems require low loss high switching power high linearity low power consumption and broad range of operating temperatures. None of the existing RF devices simultaneously meets these requirements. PIN-diodes require at least 20 mA forward bias current to be turned on they also need bias filters with bulky high-precision and expensive inductors.

MEMS are vulnerable to hot switching their switching times are limited to a few microseconds and many MEMS subtypes require high operating voltage and vacuumed packaging. Si MOSFETs and GaAs HEMTs suffer from low breakdown voltages and cannot achieve the required linearity levels.

How does it solve the problem?

The III-Nitride C3 varactor design meets all requirements mentioned above for RF control applications. C3 varactor offers high-yield simple and robust anneal-free alignment-free fabrication technology fully compatible with Power Amplifiers and the other MMICs.

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Richard Stevenson, Editor, congratulates Tim Bettles, Business Development and Marketing Manager

Richard Stevenson, Editor of Compound Semiconductor comments:

"In the RF world, a great deal of value is placed on low-loss switching, high linearity, efficiency and device operation at high temperatures. The III-Nitride C3 varactor design excels in all these areas."

METROLOGY, TEST AND MEASUREMENT AWARD

Winner: Jordan Valley Semiconductors Ltd

For: QC3 Fast HRXRD Metrology Tool

THE QC3 High-Resolution X-Ray Diffractometer (HRXRD) from Jordan Valley is a true leapfrog technology over the existing HRXRD technology within the market. The QC3 boasts more than an order-of-magnitude improvement in performance compared to other HRXRD systems, with scans taking seconds rather than minutes or even hours.

This provides LED manufacturers a dramatic improvement in quality control of LED devices, with more wafers and higher sampling within wafers possible.

The development and market launch of QC3 demonstrates the success of JVS' 2008 acquisition of Bede's HRXRD and compound semi technology.

Furthermore, it reinforces JVS management's ability to apply its business model and expertise in providing the semiconductor market with enabling, high-throughput systems with low cost-of-ownership, achieving market dominance with a valued, customer-preferred product.

Richard Stevenson, Editor, congratulates Paul Ryan, UK Site Manager

Features and benefits:

Productivity and Precision: The QC3 has a dedicated and optimised HRXRD system for LED quality control. As a result of its high intensity, the system gives higher precision and throughput compared to other HRXRD systems.

Automation: The system operates with fully-automated alignment, measurement and analysis of wafers, conducting batch wafer measurements with optional robot or multi-sample plates. The multi-sample plates allow up to 20 wafers to be loaded into the system for measurement without requiring a robot.

For the automated analysis of the data spectra, the QC3 uses tried and trusted industry-leading RADS software for automated analysis which will automatically analyse the collected data and report the results for specific wafers, batches, chambers. This reporting can be extended to host reporting if required.

Economy: QC3 incorporates XRGProtect, to ensure the tube lifetime is maximised. It also has an Eco-mode; ensuring system power consumption is reduced when there is no measurement being performed.

Simplicity and Reliability: The system is so reliable and easy to use, that no expert is required to operate the system.

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Richard Stevenson, Editor of Compound Semiconductor comments:
"X-ray diffraction is an essential characterization tool in many fabs. With many diffractometers, this process can take hours, holding back fab throughput. But that's not the case with the QC3 High-Resolution X-Ray Diffractometer from Jordan Valley, which can scan wafers in a matter of seconds."

CS MANUFACTURING AWARD

Winner: **Aixtron SE**

For: **AIX G5+ : 5 x 200mm GaN-on-Si MOCVD Reactor**

WITH its latest product AIX G5, AIXTRON SE has introduced a 5x200 mm GaN-on-Si (Gallium Nitride on Silicon technology package for its AIX G5 Planetary Reactor® platform).

Following a customer-focused development program, this technology was designed and created in AIXTRON's R&D laboratory and consists of specially designed reactor hardware and process capabilities. It is now available as a part of the AIX G5 product family and any existing G5 system can be upgraded to this latest version.

Suited for GaN power electronics as well as for LED on Si applications it addresses the industry's key requirements in a unique way:

- Highest throughput with 5x200 mm reactor capacity
- Uniformity pattern with rotational symmetry
- Behaves like a silicon single wafer reactor and therefore enables highest yields targeting greater than 95% area in spec and controlled wafer bow of 20μm min-max final bow
- Capability to use standard thickness 200 mm silicon wafers
- Industry-wide the only reactor that enables managing the temperature gradient through the wafer
- In-situ temperature profile tuning
- Customised wafer carrier temperature optimisation according to customer device requirements

What challenge does this address?

GaN-on-Si technology is the technology of choice for power electronics applications and additionally a very promising candidate for high performance low cost HB-LED manufacturing. It is assumed that LEDs on 200mm Si is the disruptive technology that enables manufacturing cost reductions of 60%, compared to today's mainstream 100mm sapphire.

The challenge was to develop a reactor that produces GaN based devices on silicon without compromising the performance or yield currently obtained on sapphire or smaller size silicon substrates. The technology must provide high-yield growth of GaN devices on large area substrates meeting the fundamental physical challenges of a strong wafer bow and crack formation as well as the reactivity of Ga with Si.

Richard Stevenson, Editor, congratulates Dr. Frank Schulte, Vice President

How does it solve the problem?

Based on extensive numerical simulation, new hardware components and processes were developed. A novel gas inlet was designed that provides unmatched gas phase stability and controllability. The setup delivers excellent process reproducibility uniformity and yield on the full area of all 200 mm wafers.

Furthermore temperature management was adapted to the requirements of the large area GaN-on-Si process. Special focus was put on the bow management. The reactor minimises the vertical heat flux through the wafer which results in the lowest wafer bow.

The specific geometry of the reactor provides rotational symmetry of the GaN films. Additionally, a reliable method to reset all chamber conditions was developed meeting the challenges of the Ga-Si chemistry.

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Richard Stevenson, Editor of Compound Semiconductor commented:

"GaN-on-silicon technology promises to revolutionise power electronics and slash the cost of LEDs, spurring a lighting revolution. One manufacturing tool that I'm tipping to play a major role in driving both these changes is the Aixtron AIX 5, a reactor that combines high throughout with impressive levels of uniformity."

SUBSTRATES & MATERIALS AWARD

Winner: **Cree Inc.**

For: **150-mm 4HN Silicon Carbide Epitaxial Wafers**

CREE INC., a supplier of SiC and GaN materials, successfully developed and introduced 150-mm 4H n-type silicon carbide, (SiC) epitaxial wafers in 2012. These high quality, low micropipe 150-mm substrates and epitaxial wafers demonstrate Cree's latest advancement in SiC technology.

Cree continues to lead the SiC materials marketplace in driving to larger diameters, as they were first to market in 75mm, 100-mm and now 150-mm wafers. This latest development of 150-mm wafers drives down manufacturing and device costs while also enabling designers to exploit the inherent advantages of SiC with larger, higher power devices.

The superior performance of SiC (10x the breakdown field of Si, 3x the thermal conductivity of Si, and 3x the bandgap of Si) enables faster switching, higher current density, higher temperature operation and higher efficiency devices. Typical applications include Schottky barrier diodes utilized for power factor correction, motor drive applications, as well as exciting recent developments in SiC MOSFETS, providing the highest energy efficiency and fastest switching speeds versus any comparable silicon power switch.

Cree's long standing commitment and investment in SiC technology offers customers a complete turnkey solution for high quality 150-mm substrates and epitaxial wafers, all delivered to customer specification with a stable, reliable and secure supply chain. SiC is a high-performance semiconductor material used in the production of a broad range of lighting, power and communication components including LED, power switching devices and RF power transistors for wireless communications.

Richard Stevenson, Editor, congratulates Chris Horton, Director, Global Sales & Marketing

What challenge does this address?

While the current industry standard SiC wafers have progressed from 75-mm to 100-mm diameter, most Silicon power semiconductor manufacturing operates on 150-mm or 200-mm fabrication lines, representing additional costs and investment. Additionally, as the industry demands smaller, lower cost and higher efficiency devices, the move to 150-mm wafers increases device yields and lowers total device cost.

How does it solve the problem?

This latest development of large diameter, high quality and highly uniform epitaxial wafers increases applications and lowers device costs, enabling significant new milestones in device cost, power density and efficiency. Ultimately, this move to large diameter, high quality material will drive wide-spread adoption of SiC within the power electronics market.

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Richard Stevenson, Editor of Compound Semiconductor comments:
"The wide bandgap power electronics market is tipped to rocket throughout this decade. Large diameter, high-quality substrates produced by Cree will help to drive this expansion."

R&D AWARD

Winner: TriQuint Semiconductor Inc.

For: Near Junction Thermal Transport Program

THE $2.7 MILLION Near Junction Thermal Transport (NJTT) program funded by the Defence Advanced Research Projects Agency (DARPA) seeks to triple the power handling performance of high power gallium nitride (GaN) transistors. Success will enable maximum exploitation of the extremely high power capabilities of GaN material. Due to significantly superior power performance per unit area of GaN transistors compared to conventional GaAs transistors, much smaller but higher power GaN monolithic microwave integrated circuits (MMICs) are gradually replacing GaAs MMICs. But the RF power utilisation in GaN is limited due to the thermal issues associated with the high power densities. GaN transistors have been demonstrated with output power capabilities in excess of 40 W/mm.

But in reality, today's best GaN transistor-based products for commercial or defence applications are utilising only 5 to 7 W/mm to keep device junction temperatures below 200 °C. That comes at a cost of relatively high gate-to-gate pitch, resulting in large chip size. TriQuint's NJTT research effort is focused on bringing highly efficient heat spreading material very close to the device junction where temperatures peak.

TriQuint's NJTT approach is based on developing GaN transistors on polycrystalline diamond substrates prepared by chemical vapour deposition (CVD). The CVD diamond substrate shows over five times better thermal conductivity than standard SiC. TriQuint extracts less than 1 μm thick active AlGaN/GaN heterostructure layers originally grown on Si substrates and attaches them to 100 μm thick CVD diamond substrates using an advanced wafer bonding technique. This enables the best known thermal spreader material to be placed very close to the device junction. TriQuint uses a proven AlGaN/GaN heterostructure to achieve 6 W/mm of RF power comparable to today's standard GaN devices.

Thermal simulation predicts that TriQuint can achieve substantially increased power handling up to three times that of today's active devices, which can enable a substantial reduction in device size or alternately allow today's standard unit cell devices to operate at significantly lower junction temperatures.

Richard Stevenson, Editor, congratulates Bryan Bothwell Strategy and Business Development Manager

What challenges are addressed?

A key challenge is to prepare GaN-on-Diamond wafers for 100mm manufacturing lines while maintaining the thermal boundary resistance at the GaN and diamond interface below a critical level while keeping the GaN surface quality suitable for good RF performance. Other challenges include attaching AlGaN/GaN films to the diamond substrates by precisely controlled adhesive bonding and developing necessary new processes to fabricate high performance devices and circuits in GaN-on-Diamond material. Simulations and other testing performed before and during the program indicate that enhanced thermal management is yielding up to 3x better power handling. Additional fabrication improvements and extensive device testing are underway to optimise the epitaxial layer transfer process and fully characterize enhancements that can be achieved in these new HEMT devices..

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Richard Stevenson, Editor of Compound Semiconductor comments:

"When it comes to thermal conductivity, diamond is gallium nitride's best friend. Uniting these two materials isn't easy, but TriQuint has made great strides in that direction. This will ultimately allow wide bandgap amplifiers to get closer to fulfilling their true potential."

Boosting GaN-on-silicon blocking voltages

A misconception is holding back the development and deployment of GaN devices that are built on silicon substrates. This platform is widely blamed for compromising blocking voltages, but it doesn't: It is possible to make diodes and HEMTs on silicon that have breakdown voltages of well over 2 kV, according to Timothy Boles and Douglas Carlson from M/A-COM Technology Solutions, Tomas Palacios from MIT and Mike Soboroff, who recently moved from the US Department of Energy to Rock Creek Strategies.

GaN HEMTs ARE ON THE VERGE of revolutionizing the power electronics industry, thanks to their capability to take device performance to a new level. Their tremendous promise has already spurred widespread academic and industrial development of transistors for power switching applications that have an impressive set of attributes: power densities of more than 2 W/mm; continuous current handling capabilities of 10 A or more; and very high reverse breakdown blocking voltages, which typically exceed 1 kV. Prototypes of these transistors have been built on sapphire, SiC and silicon – three platforms with differing pros and cons.

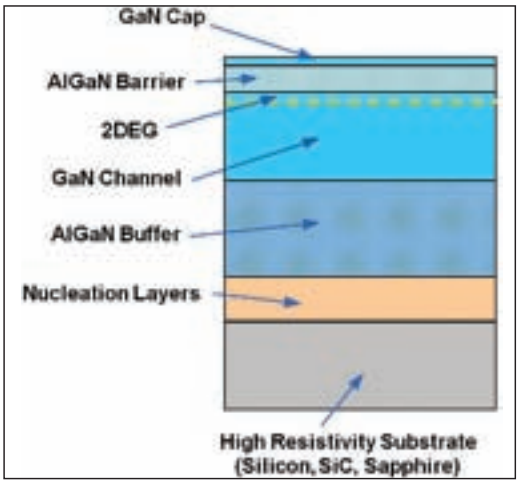


Figure 1. A typical GaN HEMT epitaxial structure

Efforts at device development have delivered much heralded, well-deserved technical successes, but this is yet to lead to significant commercial adoption of GaN. There are many explanations for this, and they tend to revolve around the view that while GaN diodes and transistors produce impressive results, they are far more expensive than their silicon rivals. Or, to put it in simper terms, they don't get close to the bang-per-buck of the incumbent technology.

This explains what is happening in the marketplace today. In this arena, the limited success of GaN products can be accounted for by citing a widely held mantra: Once the minimum level of performance needed for the application is achieved, the cheapest solution will win. So, in order for GaN-based products to realize their full potential in a broader marketplace, two changes must take place: The cost of material must plummet; and device manufacturers must target applications that cannot be addressed by lower-cost rival technologies, such as those based on silicon.

One route to driving down the cost of GaN devices involves building them on silicon and processing them in silicon lines. Staff at the US Department of Energy (DoE) subscribe to that view, and they are funding a project to investigate and ultimately commercialize GaN-on-silicon power device technology. We are all involved, and we

bring together expertise from MIT, MIT Lincoln Laboratories, M/A-COM Technology Solutions, and, most recently, Kopin Corporation.

Our goals for this project are to extend the blocking voltages of GaN-on-silicon transistors, diodes, and monolithic circuits to more than 5 kV, and to increase current carrying capability beyond 10 A. We are already well on the way to meeting this, as we have already exceeded blocking voltages of 2 kV and current handling greater than 10 A. These successes stem from focusing efforts on materials, device design and fundamental processing issues.

Lessons from the past

To understand where the GaN market stands today, it is helpful to have some knowledge of the evolution of GaAs devices in the microwave sector. Here, in the early days, the lack of commercial availability of high-quality GaAs epitaxy limited widespread adoption of GaAs-based devices. At that time – in the late 1970s and the early 1980s – many companies were essentially totally dependent on their own internally produced GaAs epitaxial wafers, and the overall marketplace was generally limited to low-volume, government-funded applications. But this situation changed completely with the introduction of multiple merchant suppliers of high quality GaAs epitaxy in the mid-1980s, and the commercialization of cellular technology, which provided a market that could not be addressed by silicon. These market conditions spawned a roadmap for exponential growth of relatively low cost, high volume GaAs devices operating at radio frequencies.

These trends in the GaAs market could be mirrored in the GaN power device sector. It is our view that these wide bandgap devices will only be cost-competitive with the incumbent technology when they are manufactured on silicon substrates, which are relatively cheap, available in wafer sizes up to 300 mm, and can be run through the lines of existing high-volume silicon foundries. As the GaN power industry moves towards this, the number of merchant suppliers for GaN-on-silicon wafers will grow, and their rivalry will push prices down as volumes take off.

We don't expect the market for GaN and SiC devices made on SiC to evolve in the same way. That's partly because there are a limited number of merchant suppliers of finished epitaxial wafers, and there are little more than a handful of SiC substrate manufacturers. What's more, the cost of SiC substrates will always be far higher than that for silicon, due to fundamental differences in the crystal growth of both materials. Growth of SiC takes place at 2100 °C, 600 °C higher than that for silicon, and laws of physics dictate that its growth rate can be up to three orders of magnitude slower than that for silicon.

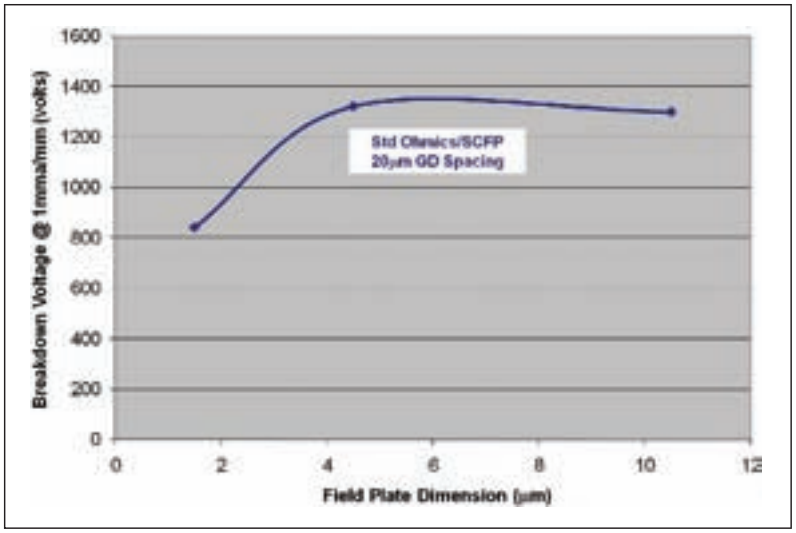


Figure 2. The breakdown voltage of a GaN-on-silicon HEMT, which has a fixed 20 mm gate-to-drain spacing, is influenced by the design of a source connected field plate (SCFP). The average breakdown value achieved at a 4.5 mm SCFP overlap dimension was 1322 V. This translates to an average field strength in the drain region of 66 V/μm ($6.6x10^5$ V/cm). The highest breakdown voltage achieved was 1632 V, corresponding to a drain field strength of 82 V/μm ($8.2x10^5$ V/cm)

Based on these fundamental differences in crystal growth, it is difficult to see how GaN-on-SiC products could ever be cost-competitive with those incorporating GaN-on-silicon technology. Then factor in the differences in substrate diameters (150 mm or less for SiC, compared with 300 mm in high volume production for silicon), along with the overall market drive of silicon versus SiC, and it is beyond question that, from a cost perspective, a silicon-based technology will always be the winner.

Market opportunities

The market opportunities for driving the sales of GaN-on-silicon epiwafers and devices fall into several categories. One is a range of power-switching applications requiring devices capable of handling 1 kV. These devices could increase the efficiency of power transmission in the grids of tomorrow, which will be integrated with a growing number of solar and wind farms. Efficiency improvements translate into cost savings of $50 billion over the next 25 years, due to a reduction of new power plant construction.

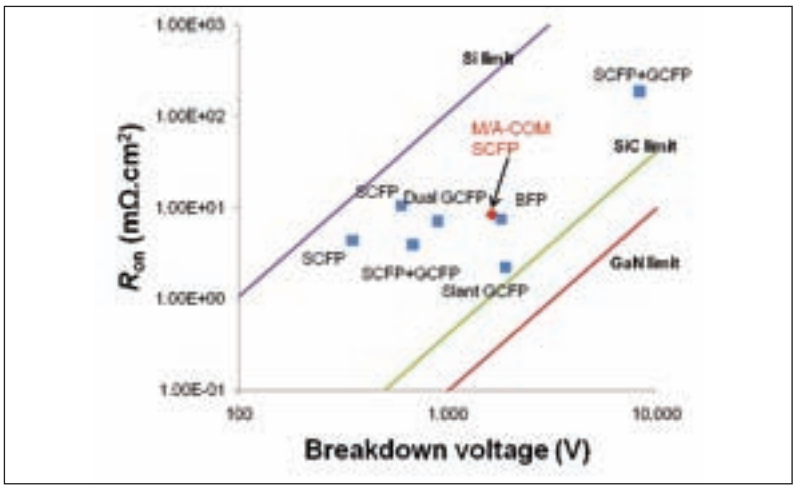
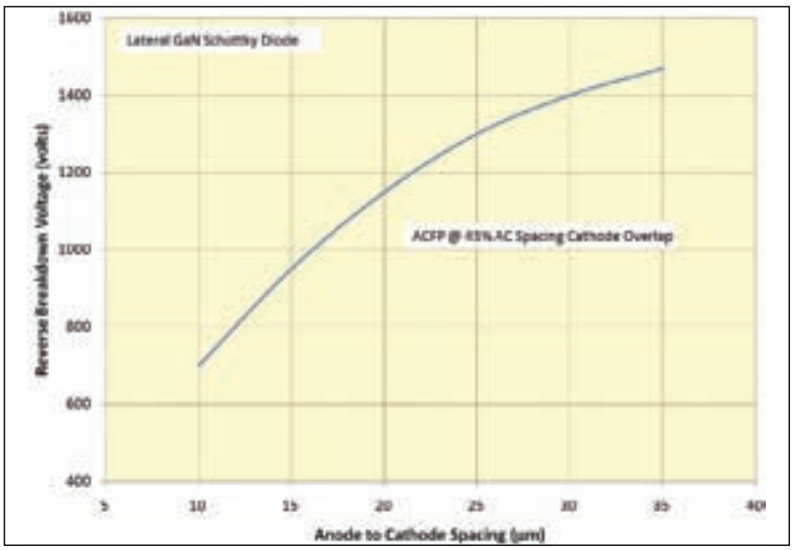


Figure 3. Material theoretical limits and a plot of R_{on} verses reverse breakdown voltage for various field plate geometries

Another opportunity for GaN-on-silicon is in electric cars, including hybrid, plug-in, and fuel cell designs. These vehicles have roadmaps though 2014 to push to a 2 kV operating bus, a move that will reduce on-state and switching losses and boost efficiency. The latter gain is highly beneficial, because it eliminates the need for a cooling loop for inverter circuitry, it increases battery life, and it delivers savings in terms of weight, volume and cost. Efficiency gains resulting from higher voltage-handling capabilities also make it attractive to deploy GaN-on-silicon devices in industrial drives, electric trains, and military and merchant fleet applications. Our low cost GaN-on-silicon technology has the potential to target all of these applications. It is based on the use of commercial GaN-on-silicon epitaxy, and involves HEMTs with an AlGaN buffer and barrier layer (see Figure 1).

These structures can be grown by either MOCVD or MBE, using a process that begins with the deposition of a nucleation layer that is unique to the starting substrate material (either silicon, SiC, or sapphire high-resistivity substrates). A relatively thick AlGaN buffering layer or super-lattice structure is then deposited onto the nucleation layer. This serves two purposes: It mitigates lattice mismatch and induced strain associated with the substrate/epitaxy transition; and it provides electrical isolation of the active device region from the substrate and substrate/epitaxy interface. Leakage from this buffer, which ultimately sets the limit for the overall device reverse breakdown, is determined by the composition and total thickness of the buffering layer.

Figure 4. Lateral ACFP GaN Schottky diode reverse breakdown as a function of anode to cathode spacing



After the buffer has been deposited, growth continues with the addition of the active GaN and AlGaN Schottky barrier layers. The aluminium fractional content in this barrier is generally between 22 percent and 32 percent, with the precise value chosen to deliver the best compromise between on-resistance and leakage characteristics. A GaN cap often completes the structure. This reduces oxidation of the underlying AlGaN film and improves the device's contact resistance.

We are by no means the only developers of GaN-on-silicon technology, but the efforts of most groups in this field have been limited to 600 V applications. This focus has led many within the power electronics industry to incorrectly believe that GaN-on-silicon devices are limited to this operating range, and GaN single-ended devices must be built on SiC if they are to deliver voltage stand-off capabilities above 1 kV. We have no doubts that GaN-on-SiC devices can operate at 1 kV and more, but they are prohibitively expensive – and we can't see that changing. Our mission is to address the misconceptions regarding the limits of GaN-on-silicon technology, and show that it is capable of creating high-blocking-voltage devices capable of carrying high currents.

Thanks to recent advances in commercial GaN-on-silicon epitaxy – especially in the construction of advanced buffer layers coupled with field plate design technology – HEMTs and Schottky diodes can now deliver standoff voltages in excess of 1.5 kV. Devices made by us can even hit much higher values than this, with GaN-on-silicon HEMTs producing blocking voltages in excess of 2.5 kV, and Schottky diodes incorporating the same materials technology delivering stand-off voltages of more than 3 kV. These levels of performance are rebuffing the accepted wisdom that GaN devices must be built on SiC, if they are to serve power electronics applications requiring enhanced voltage operation.

Our results include a portfolio of devices combining 1.5 kV blocking voltages with current handling capabilities in excess of 10 A. These

devices were fabricated from commercially produced, 100 mm diameter, GaN-on-silicon epiwafers.

Optimizing the location and dimensions of the field plate is one of the keys to realizing a high blocking voltage. The importance of this addition to the transistor is clear from plots of the drain-source breakdown as a function of the dimension of the field plate (see Figure 2).

We have also measured the on-resistance of these high-voltage GaN-on-silicon FETs, and compared this data against theoretical limits for a range of materials, and results from the technical press for various field plate design geometries and material systems (see Figure 3). This benchmarking exercise reveals that our GaN-on-silicon results compare extremely favourably with values for reported state-of-the-art devices formed on a range of substrates, including GaN-on-SiC, and various field plate approaches.

To build a circuit for high power inverters, diodes with a high reverse breakdown need to be used in conjunction with high-blocking-voltage transistors. Until now, wide bandgap diodes with reverse breakdowns of 1 kV or more have only been realized in GaN-on-SiC and SiC, but our DoE-sponsored project has shown that GaN-on-silicon is more than capable of delivering this level of performance.

Schottky diodes architectures can be divided into lateral and vertical designs, and we have focused on the former, because this enables integration with transistor structures. Pairing these two devices together holds the key to the creation of monolithic power circuits. The reverse breakdown of our devices, known as lateral GaN-on-silicon anode connected field plate Schottky diodes, depends on the anode-to-cathode spacing (see Figure 4). Optimize this, and this diode on silicon can produce a reverse breakdown in excess of 1.5 kV.

Our GaN-on-silicon devices also have values for on-resistance that compare favourably with equivalents built on other substrates and incorporating different designs (see Figure 5 for the comparison and Figure 6 for a cross-section of a typical field-plate structure). Current carrying capability can exceed 10 A, and its value can be adjusted by scaling device dimensions.

Although our device development is still in its early stages, it shows that GaN-on-silicon technology can produce HEMTs and Schottky diodes with blocking voltages well in excess of 1 kV. Thse devices should win significant sales in the power electronics marketplace, because they will be more competitive than GaN-on-SiC, which delivers impressive device results but is hampered by the limited availability of substrates and epiwafers (these are pricey and cannot scale to the same dimensions as those based on silcion).

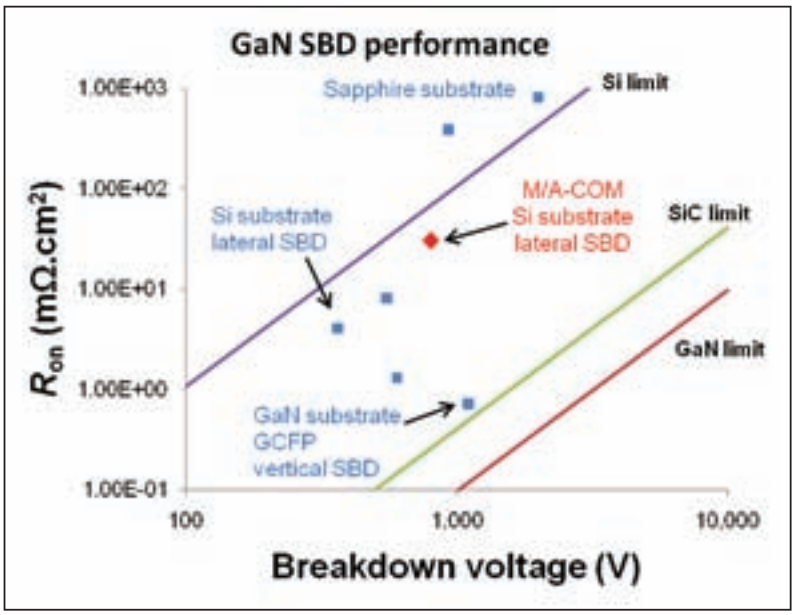


Figure 5. The GaN Schottky diode on-resistance of the device made on a silicon substrates compares favourably with those built on sapphire, SiC and single crystal GaN

The work reported here has been sponsored by Department of Energy under Contract Number DOE IA No.: DE-AI26-OE0000121 Award No. :DE-AI26-07NI43294/006

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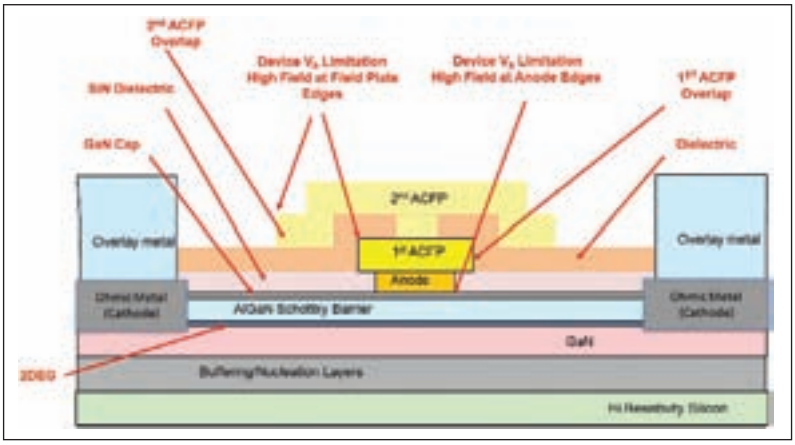


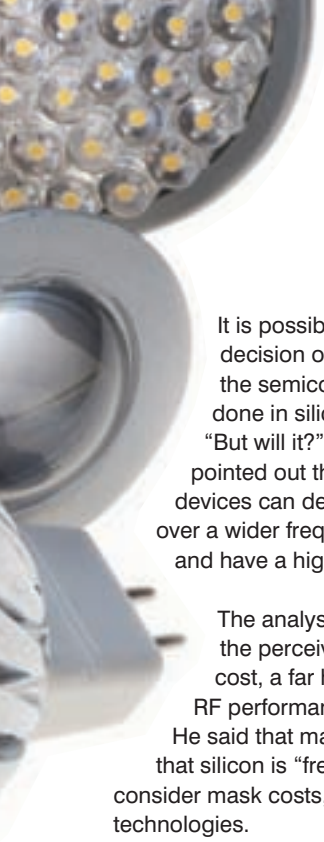
Figure 6. The anode-coupled field-plate GaN Schottky diode produced at M/A-COM Technology Solutions

Analysts address the **big issues** at **CS International**

The impact of Qualcomm's CMOS amplifier on the GaAs RF market, the steps that must be taken to make LED light bulbs affordable, and the most likely path that will be taken to enable the introduction of power electronics in the grid were all discussed by leading market analysts at CS International. Richard Stevenson reports.

TALKS FROM ANALYSTS tend to be full of facts and figures, and include plenty of graphs showing the values of markets and where they are heading. However, at CS International, the successor to CS Europe, the presentations from analysts were markedly different, focusing on some of the most important issues that are now facing the industry: Will Qualcomm's launch of an advanced RF CMOS process weaken the vice-like grip that GaAs chips have had in this sector? How can the price of LED light bulbs fall to a level that is seen as attractive by many, and will spur a revolution in solid-state lighting? And how can SiC and GaN power electronics progress, so that it can start to make an impact in the grid?

When Qualcomm announced its CMOS RF technology on 21 February, many investors in GaAs chipmakers and epiwafers vendors panicked and pulled out, causing share prices of these firms to tumble by several percent. Commenting on this state of affairs at CS International, Asif Anwar from Strategy Analytics argued that this reaction was not based on clear thinking and a critical assessment of the comparative technologies.



It is possible that investors based their decision on one widely held view within the semiconductor industry: If it can be done in silicon, it will be done in silicon. "But will it?" questioned Anwar, who pointed out that compound semiconductor devices can deliver more power, operate over a wider frequency range and bandwidth, and have a higher electron mobility.

The analyst went on to question three of the perceived benefits of silicon: lower cost, a far high level integration, and an RF performance that is rapidly improving. He said that many have the impression that silicon is "free", but that view fails to consider mask costs, which are cheaper for III-V technologies.

He then pointed out that integration is not the sole preserve of silicon, thanks to the development of many BiFET processes within the III-V industry, and he presented a table showing that while the performance gap between amplifiers made with silicon CMOS and InGaP HBT processes is closing, the efficiency of the latter is still superior by several percentage points (see Figure 1).

Both classes of amplifier are vying for deployment in cellular terminals – these are not just used in smartphones, because they also provide communication from one machine to another. Shipments of these terminals will continue to rise and could hit 2.5 billion units in 2016, according to Anwar, who expects GaAs to remain the dominate technology in this sector. " In the switch, GaAs will go away, and in discrete PAs the market will level off," claimed Anwar, but he expects the move by many GaAs chipmakers to build PA duplexers will drive strong sales for these companies. This should help to spur future annual growth of around 3 percent in the GaAs microelectronic market, which includes sales into WiFi, wireless infrastructure, backhaul and automotive radar sectors.

Slashing lighting costs

The challenges that LED makers face to drive a lighting revolution were discussed by Pars Mukish from Yole Développement. He started his presentation by pointing out that an incandescent bulb delivering 800 lumens (the typical output of a 60W bulb sold in North America) retails for less than $1, while a fluorescent sells for $3-5 and the price tag for an LED bulb is $10-50 – much more than many customers are willing to pay.

This high price is primarily due to the cost of the LED package: it accounts for 45 percent of the total cost of a downlight luminaire, and 30 percent, 55 percent and 60 percent of the cost in a LED outdoor area lamp, an LED replacement bulb and an LED replacement tube, respectively.

According to Mukish, the consensus of opinion within the industry is that the cost-per-lumen must plummet by a factor of about eight for the LED lighting market to prosper. One scenario is for manufacturing efficiency to quadruple, thanks to a combination of higher equipment throughput, increased yield and greater economies of scale, coupled with a two-to-three fold hike in LED performance. The latter could result from a substantial increase in the efficacy of the chip, and its drive current.

The industry is heading in the right direction: Prices of packaged LEDs are coming down, with high-power products falling fastest. For example, the price of a package based on a high-power 1W single chip fell by just over 70 percent between the first quarter of 2010 and the third quarter of 2012, while the price of a low power product declined by 30 percent during the same period.

It is inevitable that prices will continue to fall, and Mukish believes that the rate that they do this will be far faster if the manufacture of GaN-on-silicon LEDs takes off. According to him, savings partly stem from cheaper substrates, but the biggest benefits are associated with reductions in epiwafer and wafer processing costs.

He has calculated that costs at the die level can drop by 60 percent by switching from growth on 100 mm sapphire to 200 mm silicon, if identical epitaxial yields are realised and the silicon wafers are processed in fully depreciated CMOS fabs.

In addition to costs savings, the transfer of production from sapphire to silicon enables the introduction of a higher thermal conductivity substrate that improves temperature homogeneity. What's more, it results in a switch to a non-transparent platform, which enables more accurate measurements of surface temperature.

	Pout HPM (dBm)	Pout MPM (dBm)	PAE HPM (%)	PAE MPM (%)	Gain HPM (dB)	Gain MPM (dB)	Size
Si CMOS	26.5	16.5	37	23	28.5	18.5	3x3x?
InGaP HBT	28	16	42.5	10	28	15.5	3x3x1.0
InGaP HBT	28.25	17	46	28	28.5	23	3x3x0.9
InGaP HBT	27	16	35	28	27	19	3x3x1.0

UMTS Band I (1920 -1980 MHz)

Figure 1. Data provided by Strategy Analytics shows that amplifiers made with InGaP HBT technology deliver higher efficiencies than those made with silicon CMOS technology. HPM and MPM are high power mode and medium power mode, respectively

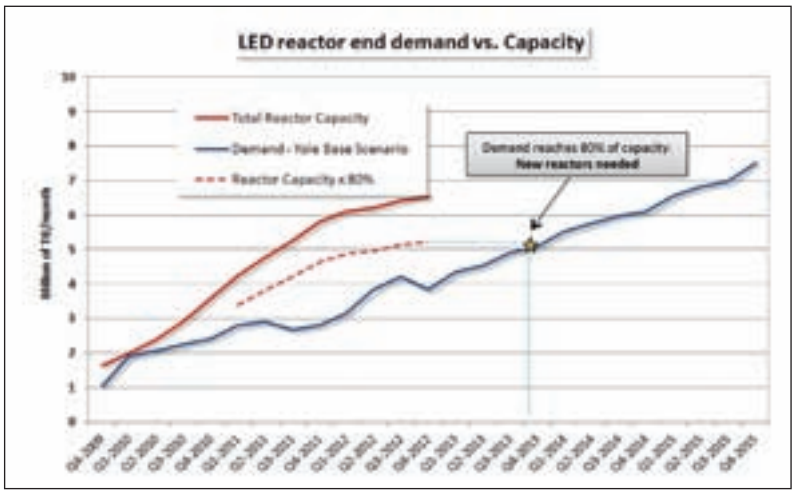
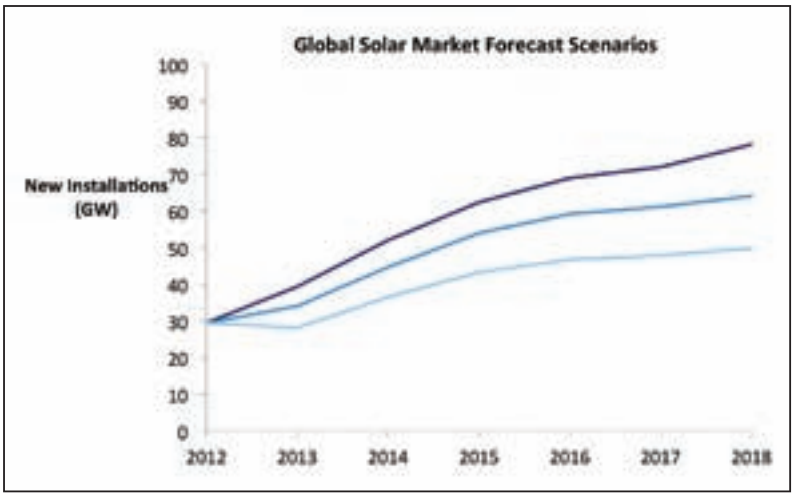


Figure 2. According to Yole Développement, the total capacity of MOCVD tools started to outpace demand for LED chips in 2010

Figure 3. Figures from IHS Research indicate that solar installation will rise throughout the decade, and show that the inverter market is a promising opportunity for the makers of wide bandgap electronics. The three traces correspond to optimistic, most likely and pessimistic predictions.

However, there are also several weaknesses associated with silicon, including greater lattice mismatch. "For sapphire it's bad, but for silicon it's even worse," points out Mukish, who adds that there are also issues associated with: melt back, which has to be addressed by depositing an AlN layer; light extraction, because silicon absorbs light and this substrate must be removed to produce high efficacy chips; and significant differences in the thermal expansion coefficients of the nitride layers and the silicon substrate that can cause the epiwafers to bow and even crack.

According to Mukish, if GaN-on-silicon LEDs are to be commercial successful, they must fulfil several criteria. The first is that they must deliver the same performance as devices on sapphire, which is not the case today, but the gap is closing. In addition, he believes that the manufacturing yields must not be compromised on silicon, and that the processing of these wafers must be compatible with CMOS silicon fabs. This means that the process should be gold-free, and ideally performed on substrates that are 725 μm-thick, although they could be thinned to meet this requirement.



Mukish also offered some insights into the LED industry in China. Driven by very attractive government subsidies, such as providing half the cost of purchasing an MOCVD reactor, the number of LED companies has mushroomed in recent years. Very high levels of MOCVD reactor shipments to this country have led to overcapacity in the global market, and it may take until the end of this year for demand to catch up (see Figure 2).

Analysis by Mukish indicates that there are about 100 LED chipmakers in China, located mainly in two regions – Fuijan and Jiangxi – and one-third of them will exit the business by 2015. These Chinese LED makers are relatively small in size – none feature in a top ten list of packaged LED companies, which is topped by Nichia and followed by Samsung LED, Osram, LG, Cree, Seoul Semiconductor, Sharp, Everlight, Philips Lumileds and Toyoda Gosei – but some companies are growing, with Murkish picking out SanAn and Eti as the most promising firms.

Sales of LED chips made in China are rising, and went up from 2 percent of the global market in 2010 to 6 percent in 2011, but overseas sales are hampered by a lack of intellectual property and the need to buy licenses from industry stalwarts, such as Nichia, Osram and Philips Lumileds. However, this is not an issue for the domestic lighting market, which will grow to be one of the biggest markets for this device in the next few years.

Gunning for the grid

Insights into the grid market for wide bandgap devices were provided at CS International by Daniel Cline from Lux Research. "It's a long-term opportunity, and we'll need to take baby steps," said Cline, who sees the solar market as a great stepping-stone.

When GaN and SiC devices are deployed in the grid, Cline expects them to make a tremendous difference to its efficiency – today 5-8 percent of electrical energy is wasted, due to a combination of line losses and switching. The addition of wide bandgap devices can drive down switching losses, which cascade along the transmission and distribution (T&D) line, from the stepping-up of the voltage at the site where power is generated, to the collection of step-down stages prior to the power reaching the end user.

Benefits of using GaN and SiC in power distribution systems extend beyond efficiency gains, and include dynamic switching that allows

re-routing when lines are down, improved voltage control and a reduction in the need for ancillary devices. What's more, when dynamic switching is used alongside sensors, it may be possible to transmit more power through existing T&D lines without causing reliability issues and outages.

Cline expects sales of SiC and GaN devices to increase in various markets through this decade, and by 2020 hit totals of $2.1 billion and $1.2 billion, respectively. A significant proportion of sales will be driven by the solar market, which is continuing to grow, with installations tipped to increase from 29.4 GW in 2012 to between 50-78 GW in 2018 (see Figure 3).

This market is seen by Cline as the "baby step" for SiC and GaN towards deployment in the grid. Solar generation takes many forms, from the production of a few kWs by homeowners; to generation of 10 kW to 1 MW by commercial systems, typically mounted on flat roofs; and utility-scale systems generating 1 MW or more. All these systems require inverters, which can operate at higher efficiencies when incorporating electronics built from wide bandgap materials.

Cline has considered the benefits of three different types of inverter, which would be used in solar installations with differing power generation capabilities: a 330 W micro-inverter, which would see deployment in a residential system; a 30 kW string invertor for a commercial photovoltaic system; and a 500 kW central invertor for utility scale systems. In the later, Cline just compared the performance and cost of SiC and silicon electronics, while in the other two cases, he considered GaN, SiC and silicon.

This piece of analysis determined that wide bandgap materials always provided energy savings, with SiC outperforming GaN (see Figure 4 for details). The biggest gains for wide bandgap devices occur in the microinvertor, where energy losses associated with silicon can be over 7 percent, compared with just over 4 percent for GaN and under 2 percent for SiC.

However, the cost-benefit associated with the addition of wide bandgap power electronics is not as significant as it is for central and string inverters, which may see the deployment of GaN and SiC components first. What is clear is that shipments of all types of invertors should grow substantially during the next few years and increase the opportunity for sales of wide bandgap electronics in the solar industry to $850 million by 2020.

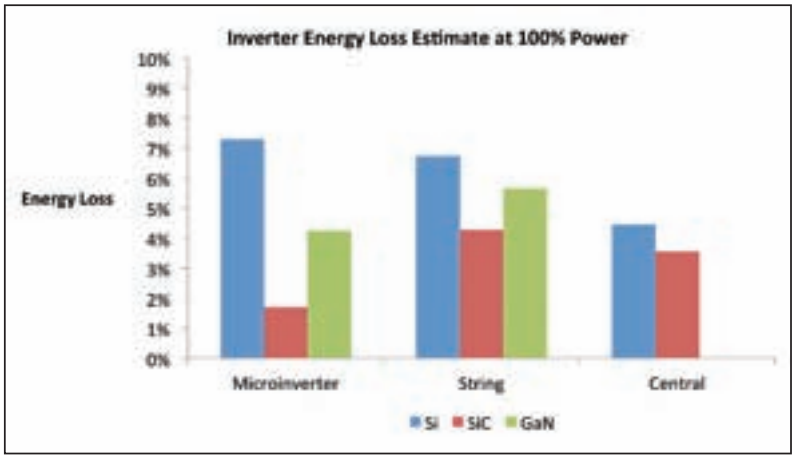


Figure 4. Analysis from IHS Research reveals that significant efficiency benefits can result from switching from silicon power electronics to equivalents built from SiC or GaN

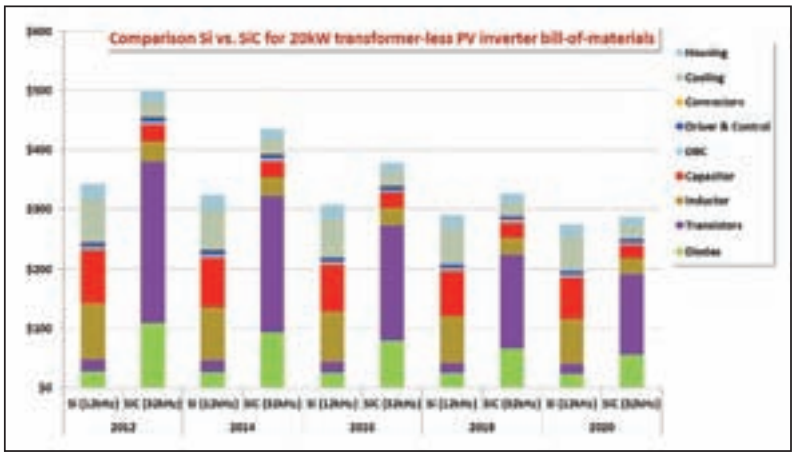


Figure 5. Yole Développement has compared the bill of materials for a 20 kW silicon-based inverter operating at 12 kHz with a system operating at the same power, but running at 30 kHz and equipped with SiC chips

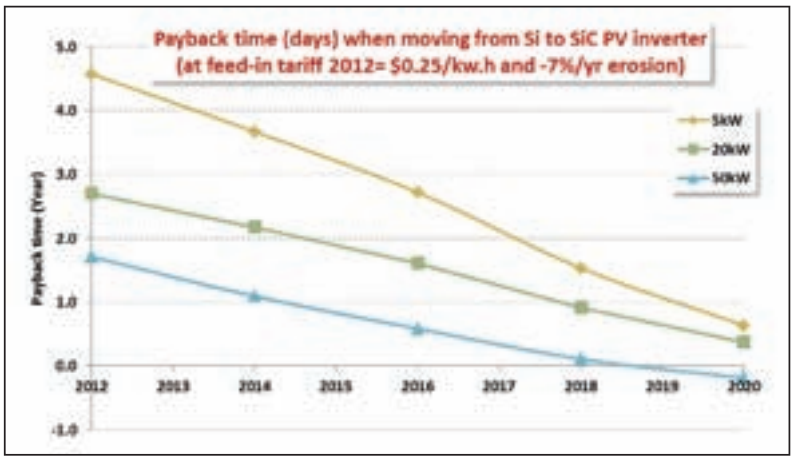


Figure 6. The payback time on the premium associated with an inverter using SiC devices, rather than those made from silicon, is falling fast, according to calculations from Yole Développement

A second opinion

Philippe Roussel from Yole Développement also discussed the opportunity for SiC devices in solar invertors in a presentation providing a roadmap for wide bandgap materials to 2020. He pointed out that SMA and RefuSol are already using SiC diodes and transistors in 20 kW inverters, which do not feature a modified architecture, operate at standard conditions, and only derive an efficiency benefit from the inclusion of SiC. Meanwhile, other companies, such as the US firms Enphase and Power One, are combining SiC diodes with silicon devices. Roussel has compared the bill of materials associated with using silicon and SiC in three different types of invertor: a 5 kW single-phase inverter, a 20 kW three-phase inverter, and a 50 kW three-phase inverter. In all three cases, the gap in the bill-on-materials between the inverter incorporating SiC and operating at 32 kHz, and that just built with silicon electronics an operating at 12 kHz, is shrinking fast (see Figure 5 for an example).

The penalty of greater expense is rewarded with higher efficiency. Roussel has calculated that payback times for investing in the SiC inverter now stand at about 18 months to 4 years, depending on the power of the inverter, and will fall substantially throughout this decade (see Figure 6).

Thanks to this improvement in the return on investment, sales of wide bandgap power electronics will increase. During this time, there will also be an increase in sales of LEDs into the lighting market, plus a growth in GaAs content in handsets. In short, the outlook for the compound semiconductor market is positive, and if all goes to plan, it should see off the threat of silicon in the mobile phone market while taking market share from it in the power electronic sector.

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GaN FETs inch closer to volume production

Like many companies around the world, RF Micro Devices and Transphorm are moving from the development of GaN FETs to their production. How far have they progressed? Richard Stevenson investigates.

THERE ARE NOW MORE than a score of companies developing GaN transistors for power electronics. All these firms share similar goals – to be a major player in this sector, and deliver high-quality, profitable products – but their backgrounds are vastly different. Some are silicon power electronics manufacturers that understand the promise of GaN; there are also those that have developed GaN for RF applications, and are looking to diversifying into new, lucrative areas; and there are also start-ups, focused solely on high-voltage GaN products.

Two firms with very different backgrounds, but similar GaN product development and manufacturing roadmaps, are: Transphorm, a spin-off from the University of California, Santa Barbara; and one of the world's biggest chipmakers, RFMD. Insights into both these US firms, which plan to qualify products this year, were provided at CS International conference held in Frankfurt on 4-5 March.

The state of play today

An honest, open assessment of where GaN transistor developers are on the road to production was provided by Yifeng Wu, Vice President of Product Development at the west-coast start-up Transphorm, which was founded in 2007.

He began his presentation by pointing out that while there is no doubt that GaN is a superior semiconductor for power electronics, and while silicon is widely believed to be the best platform for enabling this transistor to realise broad market penetration, the industry is still waiting for successful qualification of products operation at 600 V or more. Reports of success are rarely about products, and instead tend to focus on demonstrations of high blocking voltages, low static on-resistances, and the fabrication of large-diameter GaN-on-silicon epiwafers, or efforts to understand current collapse measurements.

Wu argued that although many GaN developers know that this wide bandgap material has the potential to outperform silicon, there is little evidence of this happening in prototype products that should be delivering real-world system application advantages. He put this down to a very impressive set of attributes for the latest CoolMOS technologies: "If you think you can easily out-perform state-of-the-art silicon, you are wrong."

To take on the incumbent, Transphorm has adopted a vertically integrated approach, performing epitaxial growth, wafer processing, product design and the production of discretes and modules in-house. It is targeting multiple markets: motor drives, power supplies, solar invertors, and motor invertors in electric vehicles. The modules incorporate GaN diodes and HEMTs with an AlGaN barrier. They feature proprietary GaN buffer layers for low leakage and high breakdown voltages, and they draw on the company's exclusive epitaxial technology and gate insulator designs, which are claimed to enable excellent dynamic characteristics.

"Our structure is not complicated," explained Wu, "but a lot of effort went in to making it happen." He revealed that the company has switched substrates, and is now focused entirely on making GaN-on-silicon devices. Initially, SiC was used, but this is far more expensive.

Transphorm has recently produced its first-generation GaN-on-silicon diode. Feng compared a version rated at 4A and packaged in a TO220 to SiC and silicon equivalents, which have higher turn-on voltages (1.47 V and 2.3 V, respectively, compared to 1.4 V). In addition, the GaN diode produces lower conduction loss that stems from this lower operating voltage and the device features: a lower cost than a SiC rival, thanks to the cheaper substrate; and zero minority charge, compared to 60 nC for a silicon diode. Reducing minority charge improves performance at high temperatures, and also allows the device to handle any spikes in supply voltage in a better manner. Testing shows that the performance of the diode is not impacted by 100,000 shots of 990 V spikes.

From normally off to normally on

One of the weaknesses of GaN HEMTs is that they are normally on devices, while customers prefer normally off variants, because they are considered to be safer. To address this wish, Transphorm pairs its normally on HEMT with a normally off, very fast, low-voltage silicon FET to create a hybrid that is normally off (see Figure 1). The result is a device that is compatible with silicon drivers, and claimed to combine fast switching with a low on-resistance. A novel form of wiring is used in this high-speed GaN switch. If a conventional approach were

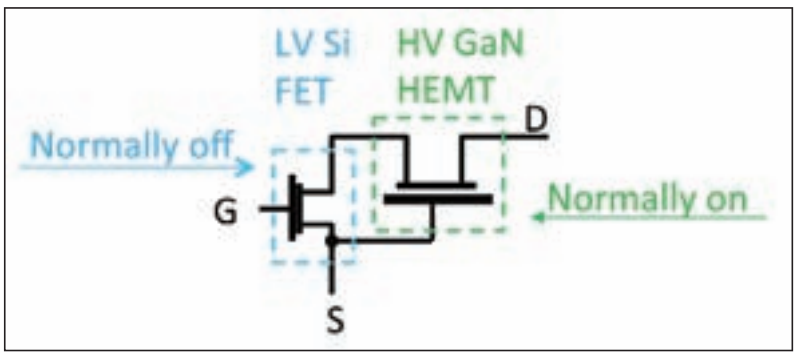

Figure 1. Transphorm pairs its normally on, high-voltage GaN HEMT with a normally off, low-voltage silicon FET to create a fast, normally off hybrid device

adopted, it could lead to spikes in the gate-source voltage that result from drain current transients. To avoid this, separate source terminals are used for the gate and drain currents (see Figure 2). According to Wu, this form of wiring configuration, known as Kelvin source wiring, is not available with silicon power T0-220 MOSFETs.

Comparisons of the current and voltage waveforms associated with high-speed switching in a CoolMOS device and in Transphorm's HEMT – both packaged in a T0-220 - reveal that spikes are significantly supressed with the wide bandgap variant. This result led Wu to claim that CoolMOS, housed in a traditional TO-220 package, is not suitable for high-speed, high-power operation. In his opinion, Transphorm's approach, known as Quiet-Tab, extends the limits of TO-220 to a new operation space. Additional strengths of this device include an on-resistance that is slightly lower than that for silicon CoolMOS, the ability to handle high voltage spikes (no change in device behaviour after 100,000 shots at 850 V spikes), and no compromise in performance after operation at elevated temperatures (no degradation observed after 1000 hours of operation at 175 °C).

In 2012, Transform submitted its GaN-on-SiC devices to qualification by Jedec, an independent, international-standards organisation. Wu describes these tests, which were passed, as very stringent: "If one device fails, qualification fails." The next step for the company is to extend its qualification to silicon-based Gan devices. "I am very positive that we will be able to qualify our devices this year," revealed Wu. Shortly after the conference the company revealed that it had meet that goal.

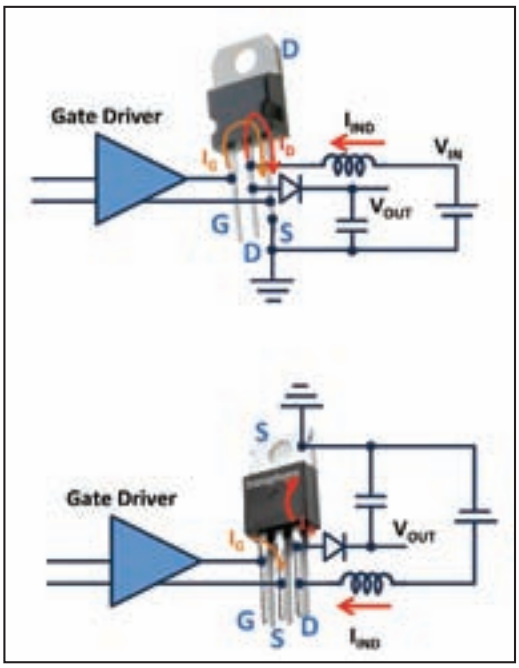

Figure 2. A conventional wiring scheme (top) leads to drain current transients that can cause current-voltage spikes. Transphorm addresses this issue with an approach known as Kelvin source wiring, which employs separate source terminals for gate and drain currents (bottom)

Wu finished his talk at CS International by highlighting the benefits that the company's devices could deliver in electrical systems. He began by considering the combination of GaN HEMTs and GaN diodes in a boost convertor, a circuit providing DC-to-DC power conversion with an output voltage exceeding its input.

Efficiencies of 99 percent were possible with this circuit that operated at 100 kHz. Compared with a boost convertor incorporating CoolMOS transistors and QSpeed diodes, device losses were cut by a third at full load (1.5 kW). When operating frequency increased to 500 kHz, the performance gap widened, with GaN trimming device loss by 70 percent, while the load had to be restricted to 1.3 kW for the silicon converter in order for this system to operate in a safe manner.

Benefits of GaN extend beyond efficiency. Chip cooling is needed to deliver the very highest efficiency, with the 1.5 kW, 500 kHz GaN convertor rising from 97.95 percent to 98.05 percent when air cooling speed increased from 0.5 m/s to 5 m/s. Delivering this load was not possible with silicon components, due to thermal runaway at the highest rates of air cooling. "[And] at 0.5 m/s, within 10 seconds the device exploded," explained Wu.

He also compared the performance of bridge circuits made from different classes of device. These can be formed without diodes when built from GaN. The speed of these wide bandgap circuits is very high – compared with silicon IGBTs, rise time is three-to-five times less, while fall time is five times less. This form of circuit has been used to build a three-phase GaN module for a motor drive invertor. This was the industry's first high-frequency module capable of 300 kHz operation, and it enabled the use of compact filters, leading to a pure sine-wave output that reduces motor stress (see Figure 4).

The benefits of Transphorm's GaN are also making an impact in the solar industry. Last December, a photovoltaic conditioner built by Yaswaka and featuring Transphorm's GaN power modules generated considerable attention at PV Japan. This 4.5 kW inverter was the smallest and most efficient at the show, with a peak rating of 98.2 percent.

RFMD's GaN development

Applications for GaN products were also discussed by RFMD's A.J. Nadler, General Manager of Power Conversion Devices, who began his presentation by reviewing what the market is worth and how fast it can grow. Nadler quoted figures from the French market analyst Yole Développement: It calculated that the power semiconductor device market was worth

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$17.7 billion in 2011 and predicts that it will more than double to $35.7 billion in 2020. In 2013, the high-voltage segment of this market - which is dominated by silicon power MOSFETs and IGBTs, but will face increasing competition from GaN and SiC devices - is worth $14.6 billion, according to Nadler, who based this figure on internal research, plus that from Yole and IMS Research.

He argued that the primary reason why silicon will not be able to see off the threat from wide bandgap products is that, in terms of device performance, it has run out of steam. Improvements since the 1970s have come from the introduction of new device structures, with the silicon bipolar transistors being surpassed by the VMOS structures in 1978, followed by the trench-MOS, the super-junction MOS and finally super-junction deep trench device.

Now, according to Nadler, the time has come when market penetration of GaN begins: "I expect things to explode in the next decade." He claims that his company is agnostic when it comes to technology, and argued that GaN will succeed because, when it comes to on-resistance, it is possible to build devices with this material that are not only one-hundredth the size of silicon equivalents, but a tenth of the size of those made from SiC.

RFMD has been involved with GaN for more than a decade, with efforts beginning with the development of RF devices. In 2001, the Greensboro-based outfit acquired GaN device developer RF Nitro Communications, and six years later it started to progress its GaN technology towards high-volume production. In 2009 and 2010 it qualified its first and second GaN process, and in 2010 it also diversified, commencing its efforts in GaN power electronics.

According to Nadler, several criteria must be met to enable the adoption of GaN in high-power electronics: the creation of a trusted, high-volume supply chain; high reliability for every device; improvements in efficiency, coupled with system cost savings that make a compelling case for buying the relatively expensive GaN components; ease of use; and a roadmap to lower-cost products. He emphasised the need for reliability by showing a picture of a 1958 transformer that was still in service, indicating that products such as this may have a replacement rate of just two per century.

RFMD is aiming to meet all these requirements with products based on its rGaN technology, which is claimed to offer efficiency-sensitive power conversion up to 900 V. Its first offering, a 650 V FET that also features an ultra-fast free-wheeling diode, operates in a normally off fashion, has an on-resistance of just 45 mΩ and can handle up to

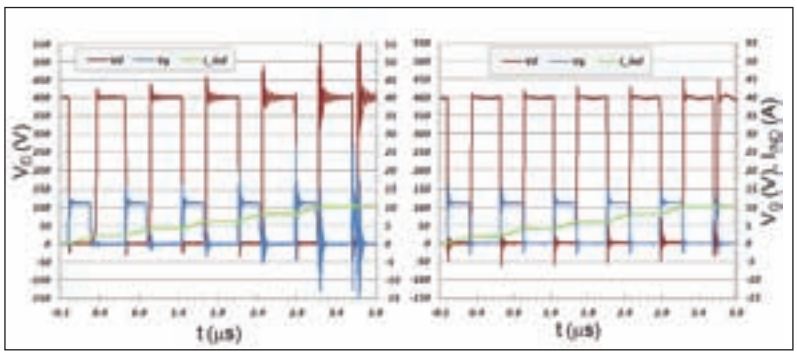

Figure 3. Compared to CoolMOS in a generic TO-220 package (right), Transphorm's HEMT that is housed in its proprietary Quiet-Tab package (left) produces far weaker spikes during high-speed switching

30A. "We are now sampling [this] to customers, and will qualify this product this year," said Nadler. One market that RFMD is targeting with its FET is the electrical system used to convert mains into a DC output for powering datacentres and high-end telecom infrastructure. This might be used, for example, to convert a three-phase AC input at 480 V into a 380 V DC output. Replacing silicon devices with those based on GaN delivers a one percent increase in efficiency. How valuable is that? Very, according to Nadler, who calculated a pay back period of just 15 months, based on the following assumptions: silicon switches cost $0.15/A, while GaN equivalents are double that; power costs $0.10 per kWhr; rated power per phase results from the supply of 20.8 A at 160V; and the units are run for 24 hours per day, and operate, on average, at half power.

RFMD is now considering the substrate that it is using to make these devices. "Everything we are doing is on SiC, but we are substrate agnostic," revealed Nadler, who said that the company is now looking at GaN-on-silicon. Transphorm has just made that transition, and many others – including the likes of International Rectifier – are already there, enjoying the benefits of the cheaper substrate. This leads to lower production costs, diminishing the additional cost of GaN devices over their equivalent silicon incumbents. The increased cost-competitiveness that results will help to drive the revolution in power electronics that RFMD, Transphorm, and many of their peers are tipping to take place throughout this decade.

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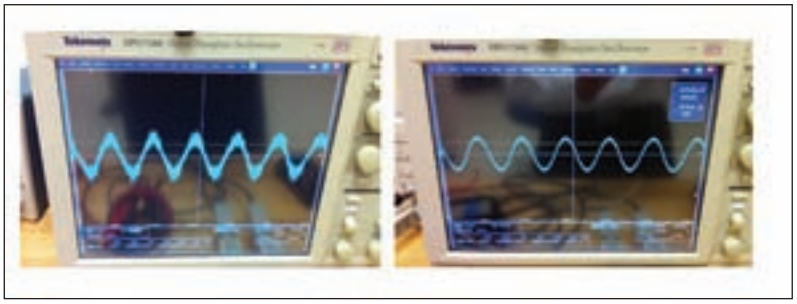

Figure 4. The waveform produced by the inverter that features silicon IGBTs (left) has a significantly more noisy output than that produced by an inverter incorporating Transphorm's GaN devices (right)

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Crystalline GaN grows on an amorphous platform

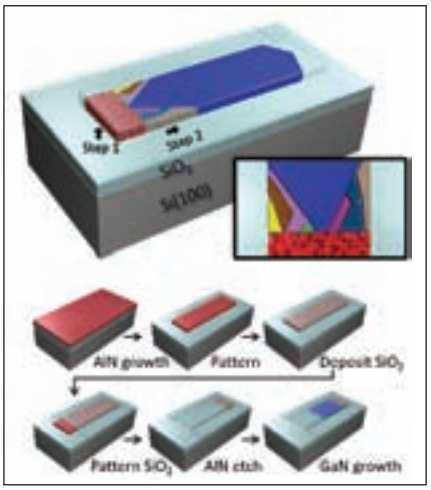
Tiny tunnels enable the growth of single crystalline GaN on amorphous substrates

YALE UNIVERSITY ENGINEERS are claiming to have produced the first crystalline, planar GaN with dimensions of tens of microns on an amorphous substrate. This accomplishment follows the recent success by engineers at Samsung, who grew nearly crystalline GaN on fused silica.

"The limitation of [Samsung's] work is that the form of GaN is necessarily pyramid-shaped, with dimensions of a few micrometres," explains lead-author Benjamin Leung. The size of Samsung's crystals, which are not orientated to each other, imposes severe restrictions on both device geometries and non-standard device processing.

structures," claims Leung, who believes that his team's technology occupies the middle ground between a top-down approach and a bottom-up one. "[It combines] the precise positioning and dimension controls of lithographic procedures with the flexibility and parallelism of a bottom-up process."

The team's process for forming GaN begins with deposition of a textured AlN film by magnetron sputtering. This film, which is fibrously textured, reduces the degrees of freedom in the material from three – randomly ordered – to just one. It features a random in-plane orientation, but includes orientational distribution along the *c*-axis. GaN deposited on this AlN film retains this characteristic,



Crystalline GaN is created on SiO_2 via growth in a tunnel formed on the substrate (see top). GaN grows laterally, on the side of AlN, which is shown in red. Confinement in two orthogonal directions leads to the formation of a large, single GaN crystal, shown in blue. The AlN stripe and the tunnel are formed through growth, patterning, SiO_2 deposition and etching steps

Vertical confinement is not optional for forming crystalline GaN. When the researchers have omitted this, polycrystalline GaN is formed along the entire length of the channel

Meanwhile, Leung and his co-workers form their single-crystal GaN on SiO_2/silicon (100) templates by a relatively complex, patented approach that involves the deposition of a textured AlN film and the growth of GaN in a tunnel. The team claims that it can routinely produce single-crystal GaN as large as 10 μm by 20 μm. They believe that this size is big enough for making some devices, including GaN FETs.

"Contemporary heterogeneous integration – for example in silicon photonics – does not emphasize planar wafer bonding or heteroepitaxy, but rather adapting to a new paradigm of preparing device islands or chiplets," argues Leung. This shift is driving interest in single crystals with dimensions that match the requirements of the device.

"We see tremendous opportunity to realise traditional and novel device

and its remaining degree of freedom is eliminated with a method that is refereed to as evolutionary selection. The result is crystalline GaN.

To form this, the AlN-coated wafer is processed into AlN stripes, before a blanket of SiO_2 is added and then partially removed to expose one end of the AlN stripes (see Figure). These stripes are etched back so that only a little material remains, creating a tunnel. GaN is then grown in this tiny cavern, along a direction perpendicular to the surface normal, which is also perpendicular to the growth axis of the initial AlN that provides a textured seed.

The engineers from Yale have formed GaN in a tunnel that is 4 μm wide, 0.65 μm high and 20 μm long. GaN is polycrystalline when it nucleates on GaN, according to electron backscatter diffraction, but it is transformed to a uniform single-crystalline grain over a distance of 4 μm, thanks to evolutionary selection. Plan-view, high-resolution, transmission electron microscopy confirms that GaN is a single crystal, with a hexagonal six-fold arrangement of the wurtzite lattice structure.

Vertical confinement is not optional for forming crystalline GaN. When the researchers have omitted this, polycrystalline GaN is formed along the entire length of the channel.

Leung says that the process that they have developed could be applied to other materials. "Unfortunately, AlN does not grow selectively in an MOCVD process, due to its high sticking coefficient, and it will randomly nucleate on the amorphous substrate." But many other materials can grow selectively and should form single crystals with Yale's process, including InN, GaAs, InP, InAs, ZnO, silicon and germanium.

The team's goals including extending its technology to other material systems and demonstrating devices based on this platform.

B. Leung *et. al.* Adv. Mater. **25** 1285 (2013)

Upping the efficiency of ultraviolet LEDs

Substrate thinning, device encapsulation and the introduction of gold interconnects takes single-chip ultraviolet LED performance to a new level

A PARTNERSHIP between engineers at Crystal IS and the US Army Research Laboratory claims that it has set a new benchmark for the performance of LEDs operating in the UVC range, which spans 100 nm to 280 nm.

"67 milliwatts at 300 milliamps and a wall-plug efficiency of 2.5 percent is the best-reported value for a single-chip LED shorter than 280 nm operated in continuous-wave," explains corresponding author James Grandusky from Crystal IS.

This advance in LED performance, which stems from improved extraction efficiency and better thermal management, will help to increase the success of this solid-state device in the ultraviolet lamp market. These chips are already being used in niche applications that do not require high output powers, and thanks to the work of the US team, they will soon be able to start competing with more powerful mercury lamps used for many different tasks.

Recent improvements to the extraction efficiency of the team's ultraviolet LEDs resulted from a combination of a substantial thinning of the substrate and the encapsulation of the device in a transparent, robust material. These modifications are claimed to propel extraction efficiency to about 15 percent – the on-wafer value is less than 3 percent.

The team fabricated its 271 nm LEDs on AlN substrates. These are often assumed to be transparent, due to their bandgap of 6.1 eV, which equates to 205 nm. However, AlN substrates feature point defects that cause absorption in the mid-ultraviolet – for a typical Crystal IS substrate the absorption coefficient is 35 cm^{-1}. This means that if an ultraviolet LED emitting at around 270 nm were fabricated on AlN that is 200 μm-thick, about half the light generated by this device would be absorbed before it reaches the substrate's surface.

One way to reduce these losses is to reduce the densities of the point defects. According to Grandusky, this should be possible, but he admits that completely removing them is probably impossible.

So the team has instead thinned its substrates, reducing them from 425 μm to just 20 μm, a step that cuts the single-pass absorption loss to less than 10 percent.

"The thinning process is straightforward, and uses similar processes to those that are used when preparing AlN substrates from boules," says Grandusky.

Encapsulated 271 nm LEDs with a chips size of 0.82 mm by 0.82 mm can lead to a continuous-wave output in excess of 60 mW

Encapsulating the device in a transparent material that has a refractive index of 1.4 also boosts light extraction, due to a reduction in refractive index contrast.

Preliminary accelerated reliability testing of the encapsulant, which is shaped as a hemisphere to aid efficient light extraction, suggests that if it were used in a 100 mW device for 5000 hours, it would show just a negligible change in transmission characteristics.

The team has enhanced the thermal management of its ultraviolet LEDs by switching from a Au/Sn eutectic alloy to a gold-to-gold interconnect process.

Devices can span the 250-280 nm range, thanks to the use of pseudomorphic growth. The 271 nm LED, which has a chip size of 0.82 mm by 0.82 mm, produced 5.3 mW, 26.2 mW and 66.8 mW at drive currents and forward voltages of 20 mA and 6.7 V, 100 mA and 8.0 V and 300 mA and 9.0 V, respectively.

External quantum efficiency of the LED is relatively constant, falling from 5.8 percent at 60 mA to 4.9 percent at 300 mA, the maximum operating current. This behaviour is very similar to previous results from pulse-driven ultraviolet LEDs, indicating that thermal droop is not a major contributing factor to the decline in efficiency with increasing drive current.

The team claims that another attribute of its UV LED is its low thermal derating – this means that it produces a small reduction in output power and efficiency with increasing junction temperature.

"A lower thermal derating allows for operation at higher temperatures without significantly lowering the output power from the device," explains Grandusky. "This also allows for operation at high input powers without significantly decreasing the efficiency of the device."

J. R. Grandusky *et. al.* Appl. Phys. Express **6** 032101 (2013)

Eliminating the buffer between InGaN and silicon

Plasma-assisted MBE growth of InGaN directly on to silicon helps the development of tandem solar cells and optoelectronic devices operating at telecom wavelengths

RESEARCHERS from the Technical University of Madrid have developed a novel approach to growing indium-rich, InGaN layers directly on silicon by plasma-assisted MBE.

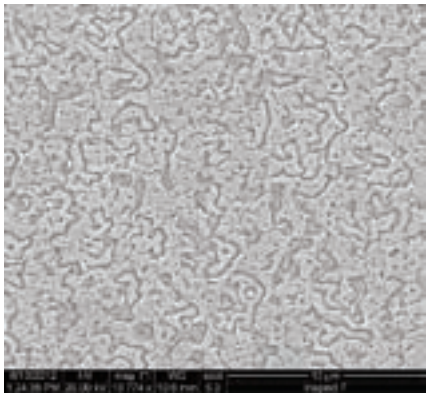
Praveen Kumar, lead-author of the paper detailing this effort, believes that their success will surprise many researchers, who believe that direct growth of InGaN on silicon is impossible.

The conventional approach to growing InGaN on silicon is to insert a buffer layer between these materials, but this has the downside of isolating the nitride film from the substrate.

"This makes novel device designs, such as InGaN-on-silicon tandem solar cells, impossible, and the direct integration of InGaN technology with silicon technology difficult and costly," explains Kumar. Simplifying and reducing the cost of integrating InGaN with silicon will also increase the attractiveness of this material system for light-emitting devices and detectors operating in the 1.3 μm and 1.55 μm telecom bands.

Films produced by the team are not homogeneous. Instead, they contain trenches and holes of pure GaN, regions with low-indium-composition InGaN, and areas with planar InGaN that are indium-rich.

"The growth of InGaN on silicon, at the early stage, always produces nanostructured layers with varying indium composition due to the selective incorporation of indium on non-planar surfaces," explains Kumar. "Therefore, our approach is not to suppress this selectivity, as would commonly be intended, but to establish growth conditions that enforce it. This makes it possible to extend the growth selectivity to macroscopic length scales for forming planar, high-indium composition layers with the desired lateral dimensions."



The textured surface created by InGaN growth directly onto silicon forms regions with an indium content of about 45 percent

One of the attributes of the high-indium-composition InGaN regions is that they can form an ohmic contact with silicon. What's more, they are claimed to be large enough to serve as templates for the realisation of InGaN/Si tandem solar cells and other planar heterostructure-based devices employing quantum well or quantum dot layers.

Deposition conditions that lead to the formation of the micrometre-sized, indium-rich InGaN planar areas include a relatively low temperature of 450 °C, and a group V to group III flux ratio just above unity.

According to Kumar, this growth window is relatively narrow. "But we are convinced that it leaves space for further improvement in the layer quality, with respect to defect generation and lateral extension."

X-ray diffraction measurements reveal the compositions of the two types of indium-containing regions: One has an indium composition of less than 15 percent, while the other has an indium-content ranging from 38-45 percent.

The indium-rich regions fail to produce room-temperature emission, due to a high level of defects that stems from plastic relaxation and coalescence.

Cool the sample to 12 K, and a photoluminescence peak appears at 794 nm, which is attributed to InGaN with an indium composition of 41 percent.

Kumar believes that it will be possible to reduce the defect density in the indium-rich InGaN layers by optimising the growth conditions.

He and his co-workers will now focus on: reducing defect density; using the InGaN layers as templates for the growth of planar heterostructures, such as quantum wells and dots; and increasing lateral extension of indium-rich InGaN through optimisation of the growth conditions.

P. Kumar *et. al.* Appl. Phys. Express **6** 035501 (2013)

Deposition conditions that lead to the formation of the micrometre-sized, indium-rich InGaN planar areas include a relatively low temperature of 450 °C, and a group V to group III flux ratio just above unity

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News Digest Contents

LEDs

NPD: LEDs to grab quarter of global lighting market

LEDs are expected to sell 16 million units in 2012 to a forecasted 33 million in 2013, and will nearly triple by 2016

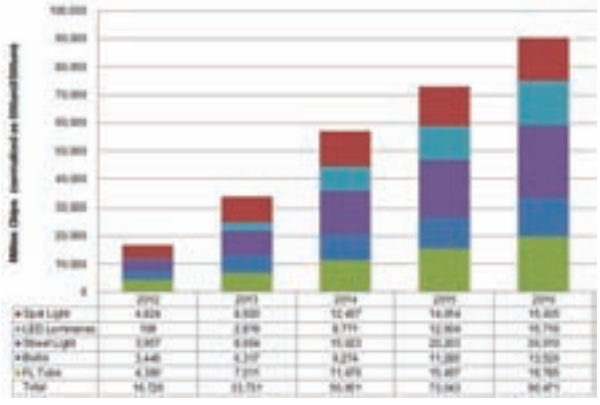
Demand for LED lighting is growing rapidly thanks to significant expansion in manufacturing capacity, falling prices, environmental concerns, and government incentives.

According to the "NPD DisplaySearch LED Lighting Market and Forecast Report", this new opportunity for LED lighting applications will double the market, from 16 million units in 2012 to a forecasted 33 million in 2013, and will nearly triple by 2016.

As a result, the demand for all LED lighting products, including spot lights, LED luminaries, street lights, LED light bulbs and fluorescent tubes, will reach 90 million in 2016, increasing the global penetration for LED lighting applications to 26 percent in 2016, up from only 5 percent in 2012.

This increase is due in large part to continued growth in commercial applications, government incentive programs, and consumer demand for energy-saving technology. The highest growth will be in LED-based tubes that replace fluorescent (FL) tubes used in commercial applications, LED-based street lights, and LED luminaires–innovative designs that produce light across various shapes and sizes.

Demand in LED Lighting Applications



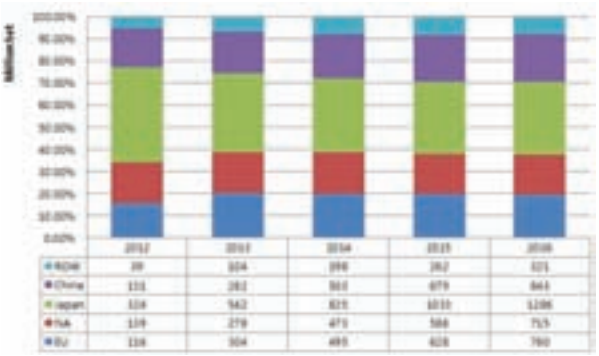
Source: NPD DisplaySearch LED Lighting Market and Forecast Report

"LEDs are playing a leading role in the lighting industry, driven primarily by government incentive policies and consumer demand for more efficient light sources with advanced technologies such as wireless and colour control," notes Steven Sher, Analyst, NPD DisplaySearch. "This increased demand will manifest over the next three years, as consumers look to replace their traditional light bulbs with more efficient LED lighting options."

Japan and China Lead LED Lighting Demand

Japan has been the largest market for LED lighting applications since 2011, and NPD DisplaySearch projects this dominance will continue through 2016, driven by the adoption of LED bulbs, spot lights, fluorescent tubes, and luminaires. LED lighting growth in China will be higher than other regions from 2012 to 2016 due to government policies such as the 12th Five-Year Plan, which is already driving demand for LED street lights. North America and Europe are also experiencing increased demand for LED lighting applications through 2016, particularly for LED fluorescent tubes.

LED Lighting Demand by Region



The market opportunity for LED lighting is playing out in the context of a stagnant market for LEDs in LCD backlighting, currently the largest application for LEDs. In 2014, general illumination will pass display backlighting as the largest application for LEDs.

What's more, the market for LED chips has been in oversupply as LED makers have invested heavily in MOCVD equipment, particularly in China. The surplus has caused competition to intensify and prices to drop dramatically, leading to higher LED penetration in lighting, but lower profits for LED makers.

This has led many LED makers to pursue vertical integration, in which the LED chip makers integrate the chip, phosphor, and control circuits to make lighting engines, and in which LED package makers integrate the lamp assembly. Success in the lighting market requires technical integration, but also optical design and the development of brand and channel strategies.

Cree leads LED lighting with a low price

Cree has reduced the price of 40W bulbs to $10

As the global market for LED products continues to expand, a race has developed among manufacturers to come out with cheaper versions of LED light bulbs to capture a bigger chunk of the consumer market.

In early March, Cree, a Cleveland-based maker of LED products, introduced a line of low-cost LED bulbs to be sold at Home Depot (HD), Investor's Business Daily reported.

One of the bulbs, a warm white 40W replacement model, sells for less than $10 at retail. That compares with $20 for some of the other lower-priced items. Cree's announcement was followed a month later by news that German lighting manufacturer Osram will launch its own 40 watt-equivalent The LED light bulb will sell for US $13.10.

The global LED market nearly tripled in size, from $5 billion in 2006 to $14 billion in 2012. Growth is expected to accelerate in coming years as key markets such as North America, Europe and China implement strategies to increase usage of LEDs, which require much less energy than traditional lighting sources.

The effort to sell lower priced LED bulbs has been hailed by analysts as an important breakthrough for the industry.

Flow mode DLS shows promise for in-line slurry particle sizing characterisation

Research engineers and scientists at Mega Fluid Systems are investigating Malvern Instruments flow mode DLS technology and developing new methods for CMP slurry.

Koh Murai, VP of Engineering, presented the initial results at the Levitronix 29th European CMP Users Meeting in Zurich, Switzerland. The main objective of the work is to determine feasibility of using flow mode DLS for in-line characterisation of CMP slurry.

The presentation covers methods and apparatus, range of application flow rates, precision, and impact of heating due to extensive recirculation. Key conclusions are flow mode DLS which is promising for in-line slurry particle sizing, and extensive recirculation did not result in measurable changes in mean particle size.

"We are very happy to take an active role in embedding leading-edge technologies, such as Malvern Instruments, into advanced particle measurement techniques critical to the CMP industry," says Jack McCann, Mega Fluid System's President. "It is yet another indication that Mega is committed to furthering our leadership position as the world's superior resource for slurry blend and delivery equipment."

Mega continues to work on challenges of flow control and accuracy of flow mode DLS.

The new method is expected to provide a platform for in-line, high precision characterisation of particle size distribution over the range 5 to 500nm featuring= chemical and slurry blend and delivery equipment to the global semiconductor, LED, pharmaceutical, specialty chemicals, and solar/PV industries.

Cambridge Uni capitalises on GaN on Silicon

A long-term collaboration for growth of 6-inch GaN-on-Si wafers is planned

The University of Cambridge has successfully commissioned another multi-wafer Aixtron Close Coupled Showerhead (CCS) MOCVD reactor at its new facility atthe Department of Material Science and Metallurgy.

The CCS 6 x 2-inch system will be configured to handle single 6-inch (150mm) wafers (1x6-inch).

"We will be using the systems to expand our research efforts for LED and electronic devices based on GaN epitaxy on 6-inch silicon wafers," comments Professor Sir Colin Humphreys, Director of Research in the Department of Materials Science and Metallurgy. "We already use one CCS 6 x 2-inch system in our work, but the gathering pace of GaN-on-Silcon development means that we need an extra system with large diameter wafer handling."

Tony Pearce, Managing Director at Aixtron Ltd., comments: "Alixtron is proud to continue its long-standing collaboration with the University of Cambridge and to supply another state-of-the-art CCS research system to complement the university's existing reactor. Under Prof. Humphreys' lead, the Cambridge group has developed world leading GaN-on-Si processes and we look forward to further supporting this work with this new system.

Frank Schulte, Vice President Alixtron Europe, adds,

"We are very pleased to announce this repeat order from Prof. Colin Humphreys and his team, pioneers of the GaN-on-Silicon technology, as they push the industry forward to success. Using silicon substrates for power electronics and LED applications, this technology should gain a big share from the existing market."

The Centre for Gallium Nitride in Cambridge,UK, not only grows nitride semiconductors, but is one of the few places in the world to have on the same site extensive advanced characterization facilities such as electron microscopy, X-ray diffraction, atomic force microscopy, photoluminescence and Hall effect equipment. The team also includes specialists in basic theory for understanding in detail the physical properties of nitride semiconductor materials.

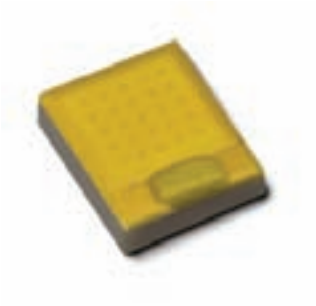
Aixtron Close Coupled Showerhead reactor

Lumileds unveils micro-mini high-power LED

The undomed module is 75 percent smaller than previous versions and gives customers more flexibility in design

Philips' newest high-power emitter, the LUXEON Z ES, offers excellent colour consistency through a 1-step MacAdam ellipse in warm white colour options.

With a micro-footprint, undomed design and full spectrum availability, LUXEON Z ES from Philips Lumileds enables high lumen density solutions with precise optical control. In applications such as retail, where superior beam angles and high efficacy are crucial, the illumination-grade emitters help lower costs while offering best in class white light.



LUXEON Z ES LED

The LUXEON Z ES is available with below blackbody binning, a key feature required for superior colour perception in specialty retail and hospitality applications. It also offers 10-15 percent superior Colour over Angle (CoA) over standard domed emitters for higher Quality of Light needs in indoor applications, making it ideal suited for lamps such as GU10, BR30, and A19 lamps.

In directional light sources such as an MR16 lamp, the undomed design allows better optical coupling for greater luminance at narrower beam angles and better colour consistency than other LED solutions.

"The LUXEON Z ES is a clear example of our commitment to innovation with the industry's first LED platform that combines high luminance in a 1-step MacAdam Ellipse option that offers optical control in the smallest available footprint," says Raj Malhotra, Product Line Manager of the LUXEON Z family. "The micro-footprint of LUXEON Z ES means that manufacturers can use optical solutions that are 25 percent smaller, yet offer the same light quality that larger, domed solutions can achieve. The LUXEON Z ES will give lighting designers incredible flexibility, reduce costs and become the foundation for light sources of the future."

The LUXEON Z and Z ES emitters are offered over a range of CCTs from 2700K to 6500K with 5-, 3- and a first-ever 1-step MacAdam Ellipse binning option, enabling next generation of high efficiency tuneable solutions with a combination of different colours, including white CCTs, lime, blue, PC amber and red. In outdoor applications, where beam angle and high efficacy are key, LUXEON Z ES also shines.

Osram LEDs awarded for innovation

The firm has won a third consecutive award from the US publication Architectural SSL Magazine

The US professional lighting journal Architectural SSL Magazine has awarded Osram Opto Semiconductors

for the third time in a row as winner of the Product Innovation Award in the category Market Leadership.

Since 2011, the magazine has honoured not only the most outstanding product innovations in the solid-state lighting sector, such as luminaires and fixtures, but also leading industrial companies.

Architectural SSL Magazine's Product Innovation Award (PIA) is awarded annually in various categories.

The Market Leadership category includes five sub-categories in which awards are given. Osram Opto Semiconductors is the 2013 winner for Industry Participation. Comprised of distinguished industrial design experts, the jury was swayed by the company's extraordinary dedication to developing a number of standards and regulations for opto-semiconductor products, and by its achievements in research and development.

The award also honours the work of Jianzhong Jiao, who as Director of Regulations and Emerging Technologies at Osram Opto Semiconductors has made a significant contribution to establishing industry standards for LED testing.

The high-tech company also was praised for making the details behind these regulations as well as other extensive and valuable information available to the SSL community on the Internet at its global LED Light Site. In the development of new products, Osram Opto Semiconductors garnered recognition for product innovations such as the Oslon SSL LED, which achieves a value of 95 on the colour rendering index.

"The fact that we have received our third consecutive PIA award reinforces our intention to continue along our chosen path," emphasises Don Klase, Chief Executive Officer of Osram Opto Semiconductors in the USA.

"These awards make us very proud, and they show the public t our committed employees are capable of. They are the ones who spend every single day enhancing existing SSL."

PowerSecure secures Solaris LEDs lighting acquisition

The acquisition strengthens and complements PowerSecure's existing LED business with additional product lines

PowerSecure International has acquired Solairs Lighting, Inc.

Solaris is a private company based in Stamford, CT which has a proprietary portfolio of LED lamps and fixtures for commercial and industrial applications. The firm provides products with excellent light output, thermal management, optics, light quality and aesthetics.

The acquisition strengthens and complements PowerSecure's existing LED business with additional product lines and an expanded customer base, and adds strong skill sets around product design, product commercialisation, manufacturing and materials sourcing.

PowerSecure paid the stockholders of Solaris $6.5 million in cash plus 675,160 shares of PowerSecure common stock and assumed approximately $0.2 million in negative working capital for a total transaction value of $15 million.

The PowerSecure shares were valued at their volume-weighted average closing sale price (VWAP) as reported on the Nasdaq Global Select Market over the five business days immediately preceding the closing date of April 12, 2013, or $12.22 per share. All outstanding shares of capital stock of Solais were exchanged for the merger consideration.

"The expertise Solais has demonstrated in developing best-in-class innovative technology in parallel with some of the most effective sourcing, procurement and manufacturing in the industry will provide us with catalysts to accelerate the growth and profitability of our LED lighting business," said Sidney Hinton, chief executive officer of PowerSecure.

"James and the accomplished Solais leadership team bring additional strength to PowerSecure and experience with distributor channel relationships that add to our new ESCO product channel and broaden our product offerings to our direct customers and utility partners," Hinton adds.

PowerSecure expects the transaction to be slightly accretive to revenues in 2013 (subject to finalisation of accounting related to the amortisation of intangible assets) and meaningfully accretive in subsequent years.

"There is tremendous synergy between our companies. With this merger, we combine the breadth, strength, innovation and success of PowerSecure with the business of Solais to accelerate our growth in the marketplace and better serve our clients. In addition, we can apply our efficient manufacturing expertise and proprietary technologies to enhance the value of PowerSecure's overall LED lighting portfolio," says James Leahy, chief executive officer of Solaris.

Optimising the harvesting of sunlight

A gallium nitride based single-photon emitter can secure communication

University of Michigan researchers have developed a new device that could make the advanced form of secure communications known as quantum cryptography more practical.

The U-M scientists have demonstrated a simpler, more efficient single-photon emitter that can be made using traditional semiconductor processing techniques.

Single-photon emitters release one particle of light, or photon, at a time, as opposed to devices like lasers that release a stream of them.

Single-photon emitters are essential for quantum cryptography, which keeps secrets safe by taking advantage of the so-called observer effect: The very act of an eavesdropper listening in jumbles the message. This is because in the quantum realm, observing a system always changes it.

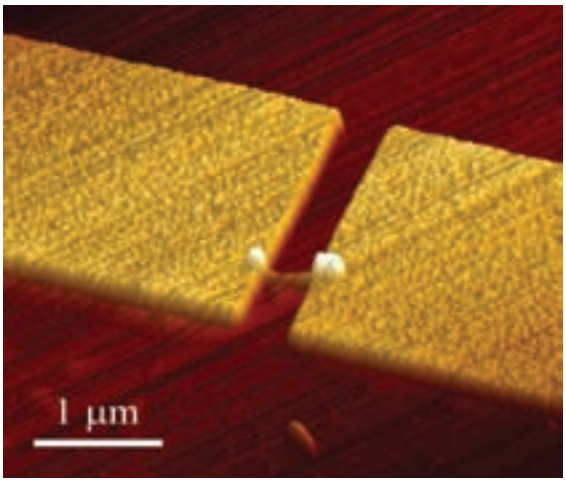
For quantum cryptography to work, it's necessary to encode the message - which could be a bank password or a piece of military intelligence, for example - just one photon at a time. That way, the sender and the recipient will know whether anyone has tampered with the message.

While the U-M researchers didn't make the first single-photon emitter, they say their new device improves upon the current technology and is much easier to make.

"This thing is very, very simple. It is all based on silicon," says Pallab Bhattacharya, the Charles M. Vest Distinguished University Professor of Electrical Engineering and Computer Science, and the James R. Mellor Professor of Engineering.

Bhattacharya, who leads this project, is a co-author of a paper on the work published in *Nature Communications* on April 9th.

Bhattacharya's emitter is a single nanowire made of gallium nitride (GaN) with a very small region of indium gallium nitride (InGaN) that behaves as a quantum dot. A quantum dot is a nanostructure that can generate a bit of information. In the binary code of conventional computers, a bit is a 0 or a 1. A quantum bit can be either or both at the same time.



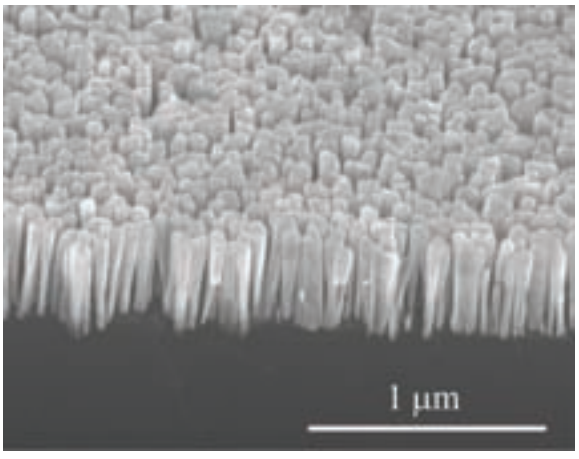
An atomic force microscope image of a nanowire single photon emitter. (Courtesy of Pallab Bhattacharya)

The semiconducting materials the new emitter is made of are commonly used in LEDs and solar cells.

The researchers grew the nanowires on a silicon wafer. Because their technique is silicon-based, the infrastructure to manufacture the emitters on a larger scale already exists. Silicon is the basis of modern electronics.

"This is a big step in that it produces the pathway to realising a practical electrically injected single-photon emitter," Bhattacharya says.

Key enablers of the new technology are size and compactness.



SEM image of nanowires growing on silicon. (Courtesy of Pallab Bhattacharya)

"By making the diameter of the nanowire very small and by altering the composition over a very small section of it, a quantum dot is realised," Bhattacharya explains. "The quantum dot emits single-photons upon electrical excitation."

The U-M emitter is fuelled by electricity, rather than light - another aspect that makes it more practical. And each photon it emits possesses the same degree of linear polarisation. Polarisation refers to the orientation of the electric field of a beam of light. Most other single-photon emitters release light particles with a random polarisation.

“So half might have one polarisation and the other half might have the other,” Bhattacharya says. “So in cryptic message, if you want to code them, you would only be able to use 50 percent of the photons. With our device, you could use almost all of them.”

This device operates at cold temperatures, but the researchers are working on one that operates closer to room temperature.

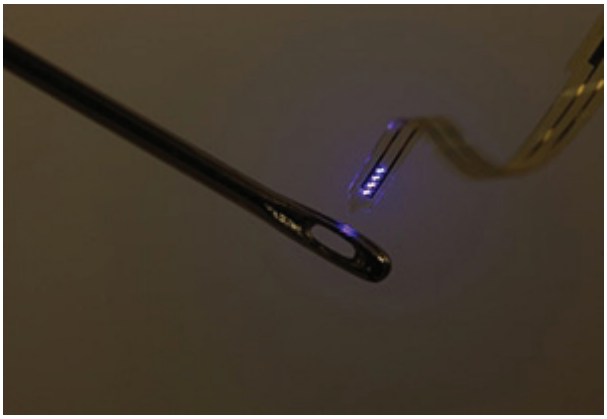
Further details of this work are in the paper, “Electrically-driven polarized single-photon emission from an InGaN quantum dot in a GaN nanowire,” by S. Deshpande *et al* in *Nature Communications*, 2013, 4. 1675. DOI: 10.1038/ncomms2691

The work is supported by the National Science Foundation. The device was fabricated at the U-M Lurie Nanofabrication Facility.

LEDs invigorate the brain

Implanting LEDs into the brain can stimulate peripheral nerves for pain management. LED devices in multiple colours may also be able to activate and control several neural circuits at once

Using a miniature electronic device implanted in the brain, scientists have tapped into the internal reward system of mice, prodding neurons to release dopamine, a chemical associated with pleasure.



Implantable LED light which can activate brain cells to release dopamine. The image above shows it is smaller than the eye of a needle

The researchers, at Washington University School of Medicine in St. Louis and the University of Illinois at Urbana-Champaign, developed tiny devices, containing LEDs the size of individual neurons.

The devices activate brain cells with light.

The scientists reported their findings on April 12th in the journal *Science*.

“This strategy should allow us to identify and map brain circuits involved in complex behaviours related to sleep, depression, addiction and anxiety,” says co-principal investigator Michael R. Bruchas, Ph.D., assistant professor of anaesthesiology at Washington University. “Understanding which populations of neurons are involved in these complex behaviors may allow us to target specific brain cells that malfunction in depression, pain, addiction and other disorders.”

For the study, Washington University neuroscientists along with engineers at the University of Illinois designed microscale LED devices thinner than a human hair. This was the first application of the devices in optogenetics, an area of neuroscience that uses light to stimulate targeted pathways in the brain. The scientists implanted them into the brains of mice that had been genetically engineered so that some of their brain cells could be activated and controlled with light.

Although a number of important pathways in the brain can be studied with optogenetics, many neuroscientists have struggled with the engineering challenge of delivering light to precise locations deep in the brain. Most methods have tethered animals to lasers with fibre optic cables, limiting their movement and altering natural behaviours.

But with the new devices, the mice freely moved about and were able to explore a maze or scamper on a wheel. The electronic LEDs are housed in a tiny fibre implanted deep in the brain. That’s important to the device’s ability to activate the proper neurons, according to John A. Rogers, a professor of materials science and engineering at the University of Illinois.

“You want to be able to deliver the light down into the depth of the brain,” Rogers says. “We think we’ve come up with some powerful strategies that involve ultra-miniaturised devices that can deliver light signals deep into the brain and into other organs in the future.”

Using light from the cellular-scale LEDs to stimulate dopamine-producing cells in the brain, the investigators taught the mice to poke their noses through a specific hole in a maze. Each time a mouse would poke its

nose through the hole, that would trigger the system to wirelessly activate the LEDs in the implanted device, which then would emit light, causing neurons to release dopamine, a chemical related to the brain's natural reward system.

"We used the LED devices to activate networks of brain cells that are influenced by the things you would find rewarding in life, like sex or chocolate," says co-first author Jordan G. McCall, a neuroscience graduate student in Washington University's Division of Biology and Biomedical Sciences.

"When the brain cells were activated to release dopamine, the mice quickly learned to poke their noses through the hole even though they didn't receive any food as a reward. They also developed an associated preference for the area near the hole, and they tended to hang around that part of the maze."

The researchers believe the LED implants may be useful in other types of neuroscience studies or may even be applied to different organs. Related devices already are being used to stimulate peripheral nerves for pain management. Other devices with LEDs of multiple colours may be able to activate and control several neural circuits at once.

In addition to the tiny LEDs, the devices also carry miniature sensors for detecting temperature and electrical activity within the brain. Bruchas and his colleagues already have begun other studies of mice, using the LED devices to manipulate neural circuits that are involved in social behaviour. This could help scientists to better understand what goes on in the brain in disorders such as depression and anxiety.

"We believe these devices will allow us to study complex stress and social interaction behaviours," Bruchas explains. "This technology enables us to map neural circuits with respect to things like stress and pain much more effectively."

The wireless, microLED implant devices represent the combined efforts of Bruchas and Rogers. Last year, along with Robert W. Gereau IV, professor of anaesthesiology, they were awarded an NIH Director's Transformative Research Project award to develop and conduct studies using novel device development and optogenetics, which involves activating or inhibiting brain cells with light.Funding for this research comes from the National Institute of Neurological Disorders and Stroke (NINDS), the National Institute on Drug Abuse (NIDA) and the NIH Common Fund of the National Institutes of Health (NIH).

Other funding comes from the McDonnell Centre for Systems Neuroscience, a National Security Science and Engineering Faculty Fellowship of Energy, a US Department of Energy Division of Material Sciences Award, and the Materials Research Laboratory and Centre for Microanalysis of Materials.

Further details of this work are described in the paper, "Injectable, Cellular-Scale Optoelectronics with Applications for Wireless Optogenetics." by Tae-il Kim *et al* in *Science,* 340, 6129, 211-216.

DOI: 10.1126/science.1232437

Intematix awarded key patent on remote phosphors

The patent will further the company's intellectual property used in LED-based lighting systems

Intematix Corporation, an innovator of phosphors and phosphor components for high-quality LED lighting, has been awarded a new U.S. patent.

Patent 8,376,580 for LED based lightingsSystems is related to the firm's remote phosphor technology. This patent marks the 21st remote phosphor patent the company has received.

This new patent contains broad and fundamental claims covering a wide variety of remote phosphor systems and applications. Allowed claims cover various two-dimensional and three-dimensional shapes used in remote phosphor systems.

Application coverage includes remote phosphor systems where the phosphor is provided as a surface layer on a carrier such as in the 2D ChromaLit and ChromaLit XT products, as well as phosphor incorporated into the bulk material for three-dimensional, or shaped, phosphor components, such as the ChromaLit Contour and ChromaLit 360 product lines.

The patent also covers the inclusion of features to enhance light extraction; further expanding the benefits of remote phosphor systems over that of conventional white LED based lighting systems.

"At Intematix we continue to invest heavily in technology development and intellectual property. We are committed to enabling high quality, energy efficient lighting, and believe that remote phosphor technology delivers both increased performance and lower costs for our customers," states Mark Swoboda, CEO of Intematix. "The continued expansion of our IP portfolio validates our

technology leadership in this area and will help to expand the growth of the solid state lighting market."

With a comprehensive portfolio of remote phosphor intellectual property, Intematix can provide lighting manufacturers with competitive advantages in the development of innovative LED systems for lighting applications

GT appoints new VP for business development

The latest addition to the team will initially concentrate on the firm's ASF equipment business. The firm's sapphire furnaces are popular with LED manufacturers

GT Advanced Technologies has taken on Linda Reinhard as vice president, new business development and product management for the company's sapphire, DSS and HiCz products.

Reinhard will report to Dan Squiller, GT's chief operating officer.

She will be responsible for leading GT's growth into new market segments and driving the product roadmap to capitalise on these new opportunities including sapphire for cover and touch screen applications.

"Linda brings deep experience and a proven track record in both product management and new business development," says Dan Squiller, GT's chief operating officer. "Linda's initial focus will be on growing our sapphire material and ASF equipment business, particularly new opportunities in the cover and touch screen markets. She has extensive experience in Asia as well as in the mobile device segment which we believe could be a significant area of opportunity for our sapphire business. Linda will also drive our product management and new business development for HiCz and our traditional PV business."

GT's Advanced Sapphire Growth Furnaces (ASF) is a production proven furnace that produces high quality sapphire material for the LED industry.

Reinhard received her BSEE from University of Illinois and an MBA from The Kellogg Graduate School of Management. She has over 20 years of experience with leading technology companies including Motorola, Cisco, Nokia, and H-P holding senior level positions in new business development, marketing, sales, and product management. She has lived in Asia and has extensive experience in China and Asia Pacific introducing new products to major OEMs.

Reinhard will be located in GT's headquarters in Merrimack, New Hampshire.

"Our goal for the show is to continue educating the market about the unique properties of GT's ASF-grown sapphire material for cover and touch screen applications," says Linda Reinhard, GT's vice president of business development and product management.

"ASF-grown sapphire's durability and resistance to scratching makes it ideally suited for a wide range of cover and touch screen applications from ruggedised phones, camera covers, point of sale devices and smartphone and touch screen devices. Other reinforced glass and cover screen technologies try to emulate what ASF-grown sapphire does naturally."

GT Advanced Technologies Inc. is a global provider of sapphire crystalline growth systems and materials for the solar, LED and other specialty markets. The company says its products and services allow its customers to optimise their manufacturing environments and lower their cost of ownership.

Seoul Semi launches LED environmental campaign

The new incentive highlights the company's eco-friendly Acrich III-nitride LED bulbs which do not require an AC/DC converter

Seoul Semiconductor is launching a global campaign called "Acrich for Trees" to actively encourage the use of eco-friendly AC LED bulbs with Acrich LEDs.

Seoul says its Acrich bulb saves two more trees than conventional DC LED solutions.

Interested parties can join the campaign from April 11th to April 30th, 2013 via the firm's official website, http://www.seoulsemicon.com.

The Campaign of planting 2 trees held by Seoul Semiconductor

Among participants who access the website and subscribe to the Seoul Semiconductor Newsletter, 1,000 subscribers will be chosen to receive a LED bulb or a LED desk lamp.

By using an Acrich LED light bulb six hours per day, annual carbon dioxide emissions are decreased by roughly 48kg compared to using a normal 60W incandescent light bulb.

What's more, the absence of an AC/DC converter (typically used in DC LED bulbs) reduces energy loss even further. Results based upon Seoul Semiconductor's internal study and data from the investigation comparing conventional and DC LED bulb solutions with an 8W Acrich bulb are shown in the table below.

Comparison between different light types

Watt	The amount of annual CO_2 emission	The number of trees for purification
60W incandescent light bulb	56	19 (16 more trees are needed)
8W normal DC LED light bulb	15	5 (two more trees are needed)
8W Acrich light bulb	8	3

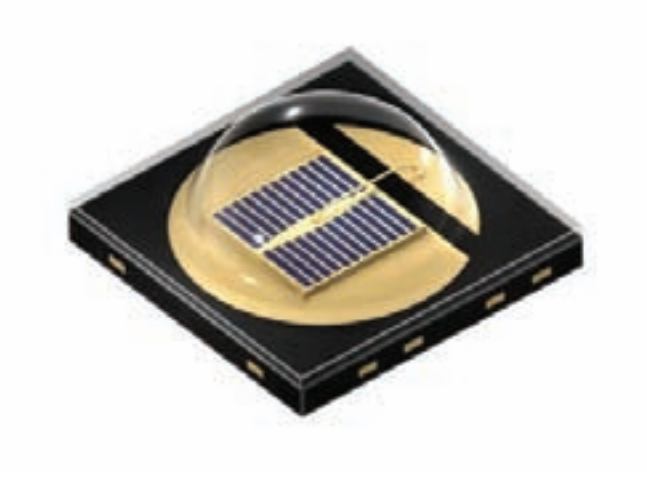
Marten Willemsen, global marketing VP, says "Seoul Semiconductor is the world's first company to succeed in developing and producing eco-friendly Acrich LEDs. This solution is more environmental friendly because it does not require an AC/DC converter. By eliminating the drawback of an analogue converter's short durability, the life expectancy of LED light bulbs has dramatically increased."

He also highlights that "This global campaign encourages people to use eco-friendly LED bulbs with Acrich LEDs to save more trees than conventional DC LED bulbs."

Osram unveils Oslon black 850nm infrared LED

The compact GaAs (gallium arsenide) based high output device is suited to computer games and optical safety systems in the automotive sector

Osram Opto Semiconductors says its new infrared (IRED) Oslon black SFH 4716S is one of the most powerful IREDs on the market with an optical output of 1030mW.



Oslon black SFH 4716S

Usually, 850nm emitting light sources are lasers rather than IR LEDs (or IREDs). Lasers emit much higher powers than LEDs and can transmit much faster signals. But lasers can also be much more expensive than LEDs.

Both 850nm LEDs and 850nm lasers are made from GaAs and AlGaAs.

Osram's latest Oslon black IRED has a beam angle of 150 degrees, and offers excellent illumination at a range of a few metres. It is therefore ideal for gesture detection systems linked to computer games or for optical safety systems in the automotive sector.

But the infrared diode is capable of even more.

With external optics and tight focusing even distant objects can be well illuminated with infrared light.

The new Oslon black is ideal wherever gesture detection is involved. This high-power IRED illuminates the relevant area so that a camera sensor can detect movement which will then be used to control a computer or enter text.

The wide beam angle of +/-75 degrees ensures that the near-field area is uniformly illuminated and gestures are reliably detected. Text can therefore be entered, for example, even if the hand is a few centimetres away from the keyboard.

The SFH 4716S is also certified in accordance with the Automotive Standard so it can be used in safety-related applications such as driver monitoring or seat occupancy detection systems in vehicles.

Its high optical output of 1030 mW is achieved at an operating current of 1A with an efficiency of around 35 percent. This increased performance is based on stack technology with which Osram provides each chip with

two emission centres, thereby doubling its output.

Oslon black achieves a radiant intensity of up to 225 mW/sr. Radiant intensity is measured in mW per steradiant. It indicates the light output within a solid angle segment and therefore defines the intensity of the light beam. The emitted light with a wavelength of 850nm is suitable for camera sensors but is barely visible to the human eye and therefore is not considered annoying.

Perfect for external optics and long ranges

The high optical output of the Oslon black also makes it suitable for combining with external reflectors. It may initially seem contradictory to create a narrow beam from a wide-angle light source but in actual fact this is a very efficient way to achieve high radiant intensity and long ranges.

The light from the SFH 4716S injects very well into an external reflector. The reflector shapes the beam so that it can be tightly focused by an additional lens. This makes it suitable for surveillance systems and monitoring systems that operate with additional infrared illumination.

“With the aid of external reflectors it is possible to produce very narrow beam angles and illuminate at distances of several hundred meters”, says Jörg Heerlein, who is responsible at Osram Opto Semiconductors for product marketing for infrared illumination.

LED Engin launches phosphor LEDs

The company’s Studio White LED emitters offer a daylight colour temperature of 5300K with a CRI greater than 85. This results in bright lighting and natural skin tones

LED Engin has launched the Studio White range of cool white LED emitters for designers of broadcast and studio lighting.

LED Engin LED modules

The application demands high CRI in daylight colour temperatures to make people look natural under artificial light. This is normally achieved using high intensity discharge (HID) arc lamps.

However, such lamps are bulky, run very hot and need high electrical voltages from which to operate, creating potential health and fire hazards. They also suffer from deteriorating performance with age. LED Engin says its Studio White emitters allow lighting designers to create fixtures that are smaller, lighter, deliver consistent performance over time, do not get excessively hot and run from safe, low voltages.

They feature a daylight colour temperature of 5300K, a colour rendering index (CRI) of greater than 85 and R9 red content of 50 which results in natural rendering of skin tones and other colours. The firm says standard daylight white LED emitters do not match this performance.

The Studio White emitters come in a range of package sizes for different power ratings from 10W to 80W, delivering between 600 and 4400 lumens output. The emitters, based on the company’s LuxiGen technology platform, have the lowest thermal resistance per footprint for reliable, high flux density designs in a sleek, small form factor.

LED Engin also offers a complementary range of total internal reflection (TIR) lenses ranging from 9° narrow spot to 50° wide flood beam versions. The compact emitter/ lens combination produces uniform lighting on the target area, smooth beam profiles and minimises light outside the target area, reducing unwanted glare compared to HID and larger LED array solutions.

David Tahmassebi, President and CEO of LED Engin, comments, “Our Studio White emitters meet the specific colour temperature and colour quality requirements of general studio lighting to fulfil a need that cannot be met with standard daylight white LEDs. These new emitters deliver best-in-class flux and colour stability over time thanks to our technically advanced LuxiGen platform.”

LED Engin’s colour offerings consist of red, deep red, far red, green, blue, amber, dental blue and white in the visible range and ultra violet (365nm and 400nm) and infrared (850nm) in the non-visible range.

The multi-chip packages are also available with multi colour / wavelength options such as RGB, RGBA or Dental Blue & UV.

CVD Equipment sells off former corporate HQ

The aim of the sale was to generate funds to increase sales and operations in the company's new 130,000 square foot manufacturing facility

On April 5th, 2013 CVD Equipment Corporation completed the sale of its 50,000 square foot facility located at 1860 Smithtown Avenue, Ronkonkoma, New York where its former corporate headquarters had been located.

The sale price of the premises was $3,875,000, representing an estimated profit of approximately $900,000 to CVD.

Leonard Rosenbaum, President and Chief Executive Officer comments, "The sale closes a chapter of our company's history and highlights a new chapter as our attention and efforts are focused towards increased sales and operations in our new 130,000 square foot facility where we will be expanding our i) Equipment manufacturing and Nano material manufacturing capabilities, ii) Pilot production process development and demonstration for the transformation of nano materials to macro sized materials and iii) Joint business/technology developments for products enabled by nano materials to be marketed through our wholly owned subsidiary, CVD Materials Corporation."

CVD Equipment Corporation) is a designer and manufacturer of customised and standard equipment used in the development, design and manufacture of advanced electronic components, materials and coatings for research and industrial applications. The firm's CVD, deposition, gas control, and other equipment is used in the growth of many materials and devices including LEDs, solar cells and III-V nanowires.

Multifunctional GaN could purify water and kill superbugs

Apart from slashing electricity consumption, gallium nitride LEDs have other potential uses

In the UK, lighting consumes over a fifth of all the electricity generated at power stations, and GaN LEDs have the potential to reduce this figure by at least 50 percent and possibly by 75 percent.

A revolution in lighting is under way. Thanks to advances in the technology, efficiency and cost of LEDs, these devices are ready to take over in the very near future from conventional forms of incandescent lighting.

The potential energy savings are huge: statistics from the US Department of Energy estimate that, by 2025, solid-state lighting such as LEDs could reduce the global amount of electricity used for lighting by 50 percent.

In the US alone, 258 million metric tons of carbon emission could be eliminated, alleviating the need for 133 new power stations, and result in cumulative financial savings of over a hundred billion dollars.

At the forefront of research underpinning this new lighting paradigm is a focus on the semiconductor gallium nitride (GaN) at the Cambridge Centre for Gallium Nitride in the Department of Materials Science and Metallurgy.

Why use GaN for LEDs?

LEDs based on GaN, which emits brilliant light when electricity is passed through it, are extremely energy efficient and long lasting. Traditional incandescent light bulbs are only 5 percent efficient at converting the electricity they consume into light, and, although low-energy light bulbs are 20 percent efficient, they contain hazardous mercury.

Compare this with white GaN LEDs, which are already 30 percent efficient and have a target efficiency of 60 percent. GaN LEDs are also incredibly long lasting: an LED can burn for 100,000 hours. In practical terms, this means it only needs replacing after 60 years of typical household use.

In the UK, lighting consumes over a fifth of all the electricity generated at power stations, and GaN LEDs have the potential to reduce this figure by at least 50 percent and possibly by 75 percent.

The Holy Grail for GaN is home and office lighting. Research directed at reducing manufacturing costs and improving the quality of light is bringing this goal closer.

Research at the Cambridge Centre for Gallium Nitride, directed by Colin Humphreys, the Director of Research in the Department of Materials Science and Metallurgy, stretches from fundamental materials studies through to applications and devices.

Green LEDs (Credit: Colin Humphreys)

The Centre has world-class GaN growth and characterisation facilities and has recently developed an innovative technique for growing GaN on large silicon wafers, instead of the more expensive sapphire wafers; this could deliver a tenfold reduction in LED manufacturing costs.

The Centre is also working on improving the quality of light by coating blue LEDs with phosphors to produce white light. This will be improved still further through the use of novel phosphors produced by Tony Cheetham in the Department of Materials Science and Metallurgy.

GaN LEDs have hit the market rapidly and are already widely used in flashlights and front bicycle lights, as backlighting for mobile phones and interior lighting in cars and aeroplanes, and even to light up landmarks such as the façade of Buckingham Palace and the length of the Severn Bridge. Looking ahead, the timescale for the widespread adoption of GaN LEDs in homes and offices is probably as short as 5 to 10 years.

Other applications also look promising. Research at the Centre is investigating the possibility of using GaN LEDs to mimic sunlight, which could have important benefits for sufferers of seasonal affective disorder (SAD).

And other studies are investigating how UV LEDs, created by adding aluminium to GaN, could be used for killing bacteria and stopping viruses from reproducing, either to purify water in the developing world or to 'sweep' hospital wards to eradicate superbugs.

The Cambridge Centre for Gallium Nitride is funded by the Engineering and Physical Sciences Research Council (EPSRC), the Technology Strategy Board (TSB), Aixtron Ltd, Sharp Electronics Europe, QinetiQ, Forge Europa, Philips, Imago Scientific Instruments and RFMD (UK) Ltd.

It is performed in collaboration with the University of Manchester and Sheffield Hallam University.

http://www.cam.ac.uk/research/news/lighting-for-the-21st-century

UPRtek measures illuminance and chromaticity of LEDs

The firm's compact spectro-radiometer measures illuminance and enables an evaluation of LEDs in terms of colour performance for sorting and binning tasks during manufacturing

The robust and reliable spectro-radiometer MK-350 was conceived by UPRtek as a cost-effective, mobile precision tool to measure, analyse and store the most important photometric parameters in the specification and qualification of LED, OLED and EL lamps and other luminares.

MK-350 LED meter

The MK-350 is well suited for field use in the light design of studios and workplaces, as well as in research and development. Distributor for Central Europe is Saleslink GmbH in Udenheim, Germany.

The system is based on a high-resolution (1 nm) linear CMOS sensor (receptor diameter 6.6mm) and an advanced spectroscopic architecture with embedded processor. Its spectral half-bandwidth is specified to approximately 12 nm. The compact (144 mm x 78 mm x 24 mm) and lightweight (250 g) instrument operates on rechargeable battery power. It performs an automatic dark calibration every time it is switched on.

The MK-350 measurement results are instantly displayed in its 3.5-inch LCD colour screen (320 x 240 pixels), which also serves as a convenient touch control interface. The instrument offers four basic operational modes:

"Basic" indicates the numeric value of the measured illuminance between 70 and 70,000 lux, the correlated colour temperature (CCT) in Kelvin, the standardised colour rendering index (CRI) expressed as Ra value (average of the first eight test colours) and the peak wavelength of the light source's radiated spectrum in nm.

In the second measuring mode, "Spectrum", the MK-350 displays a detailed graph of the spectral energy distribution in the radiated wavelength bands (between 360 and 750 nm) according to the measurement distance. Integration time is adjusted automatically or manually between 8 and 1000 ms.

UPRtek MK-250 LED meter in "Specrum" mode

The other two MK-350 operational modes, "CIE1931" and "CIE1976", provide the CIE chromaticity coordinates x and y, respectively u' and v', within their standardised CIE colour space diagrams.

Together with the measured illuminance, this enables an evaluation of LEDs in terms of their perceptional colour performance for sorting and binning tasks during manufacturing or in the field.

The MK-350 measures illuminance at an accuracy of +5 percent. Colour temperature is determined within +2 percent. Colour accuracy (according to CIE1931) is +0,0025, at a repeatability of +0,0005, both measured at 20,000 lux and 2856 K. CRI accuracy expressed as Ra is determined within +1.5 percent.

Measurement is initiated by touch control, either as one-time or continuous capture at selectable intervals. All measurement data (up to 2,000 files) are stored on an optional 2 GB SD-Card in an Excel- or bmp-compatible format.

A USB2.0 port enables easy data transfer. The built-in Li-Ion battery (3.7 V/ 2.5 Ah) ensures 5 hours of operation time. Operating temperature is 0 to 35 °C. Menu languages are Chinese (traditional and simplified) or English, with a German version downloadable shortly

Samsung launches Zhaga-compliant LED modules

The linear devices are claimed to have the highest efficacy and can be used in a wide range of applications

Samsung Electronics is introducing a new series of Zhaga-compliant LED H-Series linear modules that feature high efficacy, excellent light quality and colour consistency.

The devices have been designed for use in a wide range of lighting applications including ambient lighting and linear fixtures.

"Our new Zhaga-compliant H-Series is well suited to be used in a variety of high performance light fixtures," says Jaap Schlejen, senior vice president, LED lighting sales and marketing, Device Solutions Division, Samsung Electronics. "This leading-edge LED module series is one of several launches in a series of new LED modules with high light performance and efficacy based on advanced Samsung LED technology."

The new Samsung H-Series features 145lm/W luminous efficacy, which is the industry's highest in the LED module product category. The new LED module's 5000K CCT (Correlated Colour Temperature) provides an approximately 40 percent improvement over a typical T5 fluorescent lamp and 50 percent improvement of a T8 fluorescent lamp.

Samsung's H-Series is comprised of four types of LED modules, each with a different form factor and luminous flux to satisfy a variety of market needs. Fixture makers can connect multiple H-Series modules together for variations in luminous flux, without a gap between the modules.

Samsung will feature its H-Series at LIGHTFAIR International 2013 at booth #2645, along with other LED modules,packages, lamps and tubes.

The new Samsung LED module H-Series will be available this May.

Johnson Matthey bows out of gas purification market

This is due to a weaker LED and semiconductor market

Johnson Matthey is leaving the bulk gas purification market.

The exit regards gas purification for bulk gases using palladium membrane, heated getter or regenerable catalytic purifying technology.

Many of the products the company produces are suited to LED and compound semiconductor manufacturing.

The result will be the closure of the company's manufacturing facility in West Chester, Pennsylvania.

As a consequence, the company will begin to wind down operations at its Gas Purification Technology (GPT) business with immediate effect.

The firm also stresses to customers of Johnson Matthey's gas processing catalysts and absorbents business, which principally serves the oil, gas and chemicals sectors, that these activities are in no way related to the company's GPT business.

Johnson Matthey says it continues to stand behind its warranty obligations for previously purchased products.

Osram reveals versatile LEDs for white light staging

The company has added tuneable white multichip III-nitride LEDs to its spotlight range

Osram Ostar Stage LEDs offer a luminance of 48 million candelas per square metre (Mcd/m²) and tuneable colour tones from cold white to warm white.

Combined with a low-profile design and glass cover with an anti-reflective coating, they provide the basis for compact spotlights with an extremely narrow beam.

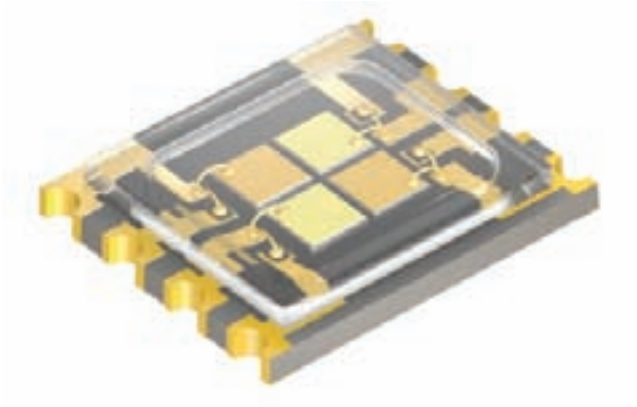
These LEDs are ideal for use in moving head spotlights on stage as shown below. They can also be used for booth lighting at trade fairs and for architectural lighting.

The special feature of the new LED is its tuneable white light colour. Two warm-white and two cold-white chips, arranged diagonally in the package, enable colours to be mixed well at component level and allow all white tones between colour temperatures of 2700 Kelvin (K) (warm white) and 10,000 K (cold white) to be produced with appropriate control.

The LED achieves a colour rendering index of 94 for warm white and 74 for cold white.

Instead of the usual lens, the LEDs have a flat glass cover with an anti-reflective coating, making them ideal for injecting the light into lens systems.

The device's etendue (the emission angle/area ratio of the emitting light surface to the projected light surface) in conjunction with external optics is retained, enabling realising a very narrow beam of light (+/- 9°).



Osram Ostar Stage LED

Osram says this beam is twice as small as spotlights based on plastic-encapsulated LEDs. Hence, the luminance of the spotlight is increased by a factor of two.

Thanks to the glass cover, the Osram Ostar Stage LED also has a much lower profile than previous standard components. At 1.23 mm, its height is only one quarter of the usual component height and its footprint is just 5.9 mm x 4.8 mm. Spotlights can therefore be made very compact.

All versions of the Osram Ostar Stage are based on the Osram Ostar SMT platform and are suitable for standard solder processes. The chips are fabricated using thin-film technology making almost all the light produced internally emitted at the top.

The LED is therefore ideal for use with external optics. In continuous operation (DC) the chips can handle an operating current of up to 900 mA. This gives maximum values of 390 lumen (lm) in cold white (10,000 K) and 210 lm in warm white (2700 K).

At a typical value of 1.8 K/W the thermal resistance is very low and heat removal is therefore not a problem. In constant use, the LEDs will last for more than 50,000 hours, giving the moving heads and architectural fixtures a long life.

Wolfgang Schnabel, LED Marketing Industrial Applications at Osram Opto Semiconductors, says, "Three versions of the Osram Ostar Stage LED are available, the Multi Color (RGBW), the pure white and

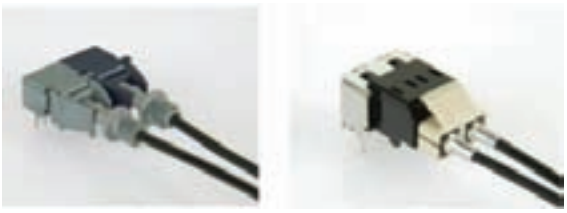
now the tuneable white. The range of applications is therefore now greater than ever before. With so many colours and configurations lamp designers have a virtually unlimited set of options."

Firecomms & Leoni to enhance fibre optic LED transceivers

The agreement between the two companies should enable customer supply chains to benefit from alternative fibre optic transceiver sources

Firecomms has teamed up with Leoni to offer its LED transceivers as an alternative to existing market-dominant systems.

Firecomms will collaborate with the Business Unit Fibre Optics of the Leoni Group to develop its RedLink LED-based fibre optic products. The devices have the option of coming with an LC connector and a connector interface that is compatible with Avago Technologies Versatile Link interface.



Firecomms RedLink transceiver and LC connector

"By collaborating with Firecomms, we can profitably combine the competences of both our companies," says Andreas Weinert, Vice President of the Business Unit Fibre Optics of the Leoni Group.

"As a result, we can offer our clients coordinated system solutions with optimised interaction of Polymer Optical (POF) and Polymer Cladded Fibre (PCF) cables, connectors, assemblies and special solutions in fibre optical technologies. Our goal is to give interested industrial companies the opportunity to qualify an alternative source of supply in order to enhance the security and flexibility of their supply chain."

Available in mid-2013, Firecomms RedLink series will include DC-1 Mb, DC-5 Mb, DC-10 Mb and DC-50 Mb transceivers with an operating temperature ranging from -40° to 85° C.

"The increasing market demand has motivated us to provide our clients a higher degree of freedom in their supply chain," adds Hugh Hennessy, Vice President Sales & Marketing of Firecomms Ltd.

"We welcome the cooperation with Leoni Fibre Optics, who can complement our product offering with their expertise as a leading supplier of optical fibres, cables and assemblies. The synergy of our RedLink with Leoni's FiberConnect product lines offers clear cost-benefit advantages for our clients."

The Business Unit Fibre Optics of the Leoni Group is one of the leading suppliers of fibre optical technology for special applications in industry, sensor technology and analytics as well as in science, communication and laser medicine.

The Business Unit Fibre Optics offers a unique product range at every stage of the value chain: from preforms and drawn fibres to fibre optic cables and complete fibre optic systems with in-house developed optical components for use in industrial, medical and telecommunication appliances.

The company has sites in Europe, America and Asia with production and support.

Osram Topleds light up buses and trains

The gallium nitride (GaN) based LEDs in the Topled package combine special features such as ESD stability and corrosion stability with a feel-good light

Osram Opto Semiconductors' new generation of Mini Topled and Topled standard packages now contain LEDs in a new brightness class.

Osram TopLED

They have a pleasant white light suited to the interior illumination of buses, trains, aircraft and cars.

And Osram says these LEDs have properties such as durability, resistance to electrostatic discharge (ESD), improved corrosion stability and certification to automotive industry standard AEC Q101. The picture below shows the LEDs used in trains.

The new generation of Topled and Mini Topled LEDs have been tailored to the demands of public and private passenger transport for high brightness and high quality. These light sources for interior illumination combine pleasant white light with a lifetime of up to 50,000 hours.

Osram claims the LEDs are among the most economical on the market because as low-power components they consume only 0.1 W. Despite their low power their luminous intensity is impressive.

From an operating current of 20 milliamps (mA) and at a colour temperature of 6000 Kelvin (K) the new Topled produces 2400 millicandela (mcd).

From the same operating current the Mini Topled achieves a typical luminous intensity of 1700 mcd at a colour temperature of 4000 K, and 1900 mcd at 6500 K. Luminous intensity in candela (cd) corresponds to luminous flux in lumen (lm) emitted by a light source in a particular solid angle.

The two new LED types benefit from further developments in chip and package technologies resulting in continual increases in light output ideally suited to automobile applications.

Apart from a high ESD resistance (electrostatic discharge) of 8 kilovolts (kV) and improved corrosion stability. The semiconductor components are certified to the automotive supply industry standard AEC Q101 and therefore meet the requirements that rail, road and air transport systems impose on components for interior lighting.

According to Nina Engel, Marketing Industry LED at Osram Opto Semiconductors, “Passengers need to feel comfortable however long their journey. LED light with different white tones helps create a feeling of well-being without compromising on brightness or durability.”

Cambridge to spend £1 million for GaN-on-silicon LED research

The presitigious university may be buying another Aixtron reactor

Gallium nitride has been described as “the most important semiconductor since silicon” and is used in energy-saving LED lighting.

Now a new £1 million growth facility will allow Cambridge researchers to further reduce the cost and improve the efficiency of LEDs, with potentially huge cost-saving implications.

It is estimated that the overall demand for electricity would fall by at least 10 percent if every home and business in the UK switched to LED lighting.

GaN LED

A new facility for growing gallium nitride (GaN), the key material needed to make energy-saving LEDs, has opened in Cambridge, enabling researchers to expand and accelerate their pioneering work in the field.

GaN-based LEDs are already used in traffic lights, bicycle lights, televisions, computer screens, car headlamps and other devices, but they are too expensive to be used widely in homes and offices.

The main reason for this is that they are normally grown on expensive substrates, which pushes up the price of LED lightbulbs.

The new GaN growth reactor at Cambridge will allow researchers to further improve a method of growing low-cost LEDs on silicon substrates, reducing their cost by more than 50 percent and opening them up for more general use.

LED technology is already so energy-efficient that it is estimated that the overall demand for electricity would fall by at least 10 percent if every home and business in the UK switched to LED lighting. This would save the UK over £2 billion per year in electricity costs. Further developments planned in the new reactor would result in

an additional £1 billion per year electricity savings.

What's more, researchers are developing colour-tuneable LED lighting, which would have the quality of natural sunlight, bringing considerable health benefits to users.

University scientists are also starting to investigate the potential of GaN in power electronics, which it is thought could have similarly significant energy-saving consequences. This could cut nationwide electricity consumption by another 9 percent.

The reactor, which is funded by the Engineering and Physical Sciences Research Council (EPSRC), was opened on March 28th by David Willetts MP, the Minister for Universities and Science.

It marks the latest chapter in a decade-long research project to make LEDs the go-to technology for lighting, led by Professor Sir Colin Humphreys in the University's Department of Materials Science and Metallurgy.

In 2003, Humphreys and his team began experimenting with the possibility of growing GaN on silicon instead of costly sapphire and SiC.

After years of research, they developed a successful process, and in 2012 this was picked up by the British manufacturer, Plessey, which has already started to manufacture LEDs at its factory in Plymouth, based on the Cambridge technology.

Plessey also hired three of Humphreys' post-doctoral scientists to help transfer the process. It is the first time that LEDs have been manufactured in the UK.

LEDs are a more efficient technology for lighting because they waste less energy as heat. As a result, they need less electricity overall, and this has a knock-on effect for carbon emissions, because nearly all the electricity in the UK is produced by burning fossil fuels.

A traditional tungsten filament lightbulb, for example, is extremely wasteful - converting just 5 percent of its electricity supply into light. Fluorescent tubes, by contrast, are 25 percent energy efficient and compact fluorescent lamps (used as low-energy lightbulbs) are 20 percent efficient. GaN based LEDs, however, are already 30 percent energy efficient and 60 percent efficiency has been achieved in laboratory research.

"At the moment, a 48-watt LED lightbulb, made from GaN on sapphire LEDs, costs about £15," Humphreys says. "That's a cost that you make back several times, because the bulbs last for so long, but it is too much to convince most customers to buy them. The research we have already performed on GaN on silicon LEDs, plus that which we will carry out in this new reactor, will mean that soon people will be able to buy an LED bulb for just £3 instead."

Minister for Universities and Science David Willetts adds, "LEDs are highly energy efficient but expensive to produce, meaning their domestic use is limited. This excellent new facility will enable researchers to look at more cost-efficient ways to produce LEDs, saving money and benefitting the environment. It will also help keep the UK research base at the very forefront of advanced materials, which is one of the eight great technologies."

Making GaN LEDs more cost-effective could unlock benefits far beyond energy saving alone. Humphreys is investigating the possibility of "smart lighting" - a system in which LED lights coupled to a sensor would be able to switch themselves on and off, or alter their brightness, relative to a user's presence or levels of natural daylight in a room.

As their use increases, the beams from LEDs could be used to transmit information, for example from traffic lights to cars. "It's conceivable that the two could be developed to talk to one another," Humphreys said. "Traffic reports, such as information about a road accident, could be sent to traffic light systems. They could then relay the details to drivers by transmitting it through the headlamps."

Researchers also believe that LEDs could be used to purify water supplies in the developing world. Deep ultraviolet (UV) radiation kills bacteria and viruses. By putting a ring of ultraviolet LEDs around a water pipe at the point where it enters a home, it might be possible to kill off bacteria in the water as well as other undesirable organisms, such as mosquito larvae.

Further energy-saving with LEDs may also be possible. Humphreys and his team are currently investigating the so-called "green gap" problem which could improve the way in which they make white light. The LEDs currently used to make white light are in fact blue - the colour is changed using a phosphor coating. This phosphor is, however, not completely energy efficient, and a better way of making white light could be by mixing blue, red and green LEDs together instead.

This, however, depends on resolving lower efficiency in green light compared with the other two colours. If this can be addressed, and LEDs made the standard for lighting nationwide, then it is estimated that there would be an additional electricity saving of 5 percent - on top of the 10 percent likely to be engendered by switching to LED technology in the first place.

As well as being used to make affordable, efficient LED lighting, researchers believe that Gallium Nitride could

also improve the efficiency of "power electronics" - shorthand for a wide range of devices, circuits, and systems that manage electrical energy. Although power electronics are rarely seen, they affect the daily lives of most people. For example, such devices manage the battery lives of mobile phones, maximise the efficiency of transmission lines, regulate the power in washing machines, and are found in computers, cars and aircraft engines, to name but a few.

At the moment, such electronics are made from silicon, but Humphreys argues that they could be made from Gallium Nitride. As with lighting, the use of GaN would improve their energy efficiency. He and colleagues from several other British Universities have just been awarded a grant by the Engineering and Physical Sciences Research Council (EPSRC) to develop and prototype highly efficient, GaN power electronic devices that could underpin new applications in sectors such as the automotive, aerospace, consumer electronics, lighting, healthcare and energy industries.

"If we can replicate these devices with Gallium Nitride electronics, we believe that we could make them 40 percent more efficient," he said. "That in itself would translate into a 9 percent electricity saving in the UK, if applied across the board."

Aixtron supports LED and laser research at Peking University

The institute has purchased another reactor (3 by 2 inch) to grow aluminium gallium nitride (AlGaN) based products

China's Peking University has ordered another Aixtron MOCVD reactor.

The Close Coupled Showerhead (CCS) reactor has a capacity for three 2-inch (3 x 2") substrates in a single run.

The order was made in the second quarter of 2012 with delivery scheduled for the first quarter of 2013.

Aixtron Close Coupled Showerhead (CCS) Reactor

One of the researchers who will be using the Aixtron system is Shen Bo. He says, "We already have an Aixtron CCS system in use, and we are very satisfied with it. We now needed a system to improve our UV LED and laser research. The aluminium gallium nitride (AlGaN) material growth needed for this is very challenging due to the very high temperatures of more than 1200°C required. Also AlGaN is very difficult to dope, particularly with magnesium that is used to create the *p*-type regions needed for hole injection."

Aixtron's Close Coupled Showerhead (CCS) concept is suited for small scale production and R&D. Processes are easily scaleable to larger systems. Aixtron says the stable platform comes with excellent reliability, ease of use and reproducibility.

Founded in 1898, Peking University (PKU) was the first national comprehensive university in China. At the end of the 20th century, the Chinese government placed PKU at the top of the agenda for promoting higher education, with a view to making it a world-class university by the 21st century.

Supported by the government, Peking University has made great progress in cross-disciplinary programming, talent nurturing and scientific research.

Cree shrinks its SiC based XLamp XQ LEDs

The firm says its silicon carbide based devices offer compactness and superior light distribution

Cree is marketing its new product family, the XLamp XQ LEDs.

These compact modules offer novel light distribution and high reliability, enabling broader light distribution such as

those used in omni-directional lamps and fixtures.

The XQ LEDs are Cree's smallest lighting-class LEDs measuring just 1.6mm x 1.6mm. This is 57 percent smaller than Cree's XLamp XB package.

Built on Cree's SiC-based SC3 technology platform, the ceramic-based XQ LEDs are designed to deliver the long-term calculated lifetimes of Cree's other high-power LEDs, such as the XP or XT LEDs.

The difference with the XQ LEDs is that a new light emitting pattern directs more light towards the edge rather than the centre of the package.

Cree says that compared to existing LEDs, XQ LEDs allow fewer packages to achieve a wide, distributed light pattern. Together, these innovations can enable manufacturers to increase the light output, expected lifetime and omni-directionality of their designs.

"The high reliability of the ceramic based XQ-B LED allows us to offer a high quality solution that does not compromise on lifetime," says Martin Hockemeyer, Vice Chairman of the Board of TELEFUNKEN Licht AG. "The unique optical advantage of the XQ-B gives us the opportunity to create the brilliant look that our customers are looking for."

"Once again, Cree is creating innovative solutions to allow our customers to differentiate their products," says Paul Thieken, Cree director of marketing, LED components. "Unlike other mid-power packages, the XQ LEDs allow lighting manufacturers to meet their light distribution requirements using fewer LEDs without giving up the performance or reliability that they expect from Cree's lighting-class LEDs."

The XQ family includes two new LEDs, the XQ-B and the XQ-D.

In cool white (5000K), the XQ-B LED delivers up 160 lumens-per-watt at 0.18W.

The XQ-D LED delivers up to 130 lumens-per-watt at 1W.

Both LEDs are available in 2700K to 6500K colour temperatures with a minimum 80 CRI option.

Cree XLamp XQ LED samples are available now and production quantities are available with standard lead times and can be ordered on the firm's website.

Cree's LED street lighting performance increases by 15 percent

The firm's latest III-nitride LEDway Series provides a cost effective way of replacing high pressure sodium and metal halide fixtures

Cree has made a performance upgrade to its LEDway Series LED Street Light.

These luminaires, provided in several versions and tailored to specific applications, are a good replacement for outdated high pressure sodium (HPS) and metal halide (MH) fixtures.

Providing significant improvements over the prior LEDway Series, select versions of the new LEDway Series LED Street Lights provide up to 20 percent additional energy savings and increased lumen output, while other versions provide up to 15 percent higher lumen output and additional energy savings. These improvements can help municipalities reduce operating cost where budgets are tight - lowering the total cost of ownership while providing the same illumination performance.

"Cree is committed to helping municipalities and facility owners lower their lighting energy costs and maintenance expenses," explains Greg Merritt, vice president, lighting at Cree. "The increased performance of the new LEDway Series can improve payback up to 25 percent compared to the previous generation and strengthens the argument to replace antiquated lighting technologies. These cost savings can greatly benefit municipalities and free up money for other expenses."

Engineered to optimize illumination and economic performance, Cree LEDway Street Lights have a ten year warranty and offer more than 20 optical distribution patterns, flexible drive currents and multiple lumen packages.

Rubicon awarded asymmetrical wafer configuration patent

The company is providing tactile and visual indicators for sapphire wafer orientation

Rubicon has been granted its "Asymmetrical Wafer Configurations and Method for Creating the Same," U.S. Patent No. 8,389,099 by the United States Patent and

Trademark Office (USPTO).

The patent covers the creation of visual and tactile indicators to make sapphire wafers asymmetric according to their crystalline orientation.

Sapphire wafers have a specific orientation that is invisible to the naked eye.

Rubicon has developed a simple and elegant process to make wafers appear asymmetrical via visual or tactile inspection.

This is important as LED and semiconductor manufacturers process sapphire wafers using specific crystalline orientations.

Rubicon maintains this patent will help manufacturers in the LED and SoS / RFIC industries eliminate costly and unnecessary steps to determine orientation of sapphire wafers during processing, such as X-ray crystallography.

Epitaxy-ready wafers have either an orientation flat or an orientation notch, but this provides insufficient information. One problem is that the wafer could be flipped front-to-back and still look the same yet be unusable in that state crystallographically.

Only through repeated X-ray inspections could one ensure that no wafers are reversed. If the wafers are made asymmetrical, operators at each stage of production can verify surface orientation quickly and economically, and will be confident that the wafers have been handled correctly.

Rubicon's patent demonstrates several different solutions for making sapphire wafers asymmetric.

One scenario is a rounded corner on the orientation flat or notch which allows a user to easily determine that the wafer has not been reversed. In another solution, both corners of the flat are rounded to different radii.

These differences are enough to determine orientation by touch or visual inspection. The technique can be applied to other substrates including silicon, silicon oxide, AlN, germanium, SiC, GaAs, GaP, GaN, and amorphous analogues.

"This new patent demonstrates our ongoing commitment to refine our products for our customers and deliver innovations that deliver real value," says Raja M. Parvez, President and CEO of Rubicon Technology. "For Rubicon's customers in the LED and SoS / RFIC markets, the crystal orientation is a critical factor in their manufacturing processes. This patent provides a simple and elegant solution to eliminating costly mistakes in the processing of sapphire wafers."

"It underscores our dedication to not only provide high quality sapphire wafers, but to provide our customers with added value to lower the total cost of LED and RF solutions," he adds.

Cree breaks the 10,000 lumen barrier

With its extended family of integrated III-nitride LED devices, the firm claims its CXA LEDs deliver the industry's highest efficacy lighting-class arrays

Cree has extended its XLamp CXA family of integrated LED arrays with the new higher-light-output CXA2540 and CXA3050 LEDs.

Optimised to simplify designs and lower system cost, the CXA LEDs deliver 5,000 to over 10,000 lumens, enabling new applications such as high-output track lights and downlights, outdoor area lighting and high-bay lighting.

The Cree CXA3050 LED is now the brightest member of the CXA family and can enable LED replacements for up to 100-watt ceramic metal halide in spot lighting or up to 175 watt pulse-start metal halide in high-bay and outdoor area lighting.

The addition of the CXA3050 LED Array also enables lighting manufacturers to rapidly expand their product portfolio with higher-lumen products.

The CX2540 LED delivers up to 20 percent higher efficacy at 5,000 lumens and 3000 K than competing LED arrays of similar size. This device also shares the same mechanical package as the existing CXA2520 and CXA2530 LEDs, giving manufacturers access to the same connector and optics solutions available today.

"We really like the ease-of-use and high performance of the CXA family, and we're looking for higher-lumen versions to address the high-bay lighting market," says Jong Hyun Woo, chief project manager, ILSUNG Ltd. "The CXA3050 LED Array gives us the performance that we need together with the high reliability that Cree is known for to create compelling designs for our customers."

The CXA2540 and CXA3050 LED Arrays use the same proven package technology as the CXA1507 LED, which now has 6,000 hours of LM-80 data published and is able to support TM-21 calculated lifetimes of greater than 130,000 hours at binning current and greater than 85,000 hours at maximum current. This long-term calculated lifetime exceeds many other LED Arrays and plastic mid-power LEDs used today.

"Cree is the only LED manufacturer that can deliver industry-leading performance and reliability in all types of LED packages," comments Paul Thieken, Cree director of marketing, LED components. "The CXA family of integrated arrays enables lighting manufacturers with an easy-to-use, single-LED solution without compromising light output, efficacy or long-term reliability."

To help lighting manufacturers get started designing with the new CXA integrated LED arrays, Cree has also published three CXA-based LED reference designs: PAR30 replacement lamp, six-inch downlight and retail track light. In addition, the new CXA LEDs are available in EasyWhite colour temperatures, providing the LED industry's best colour consistency for designs that use only one LED.

XLamp CXA2540 and CXA3050 LED samples are available now, and production quantities are available with standard lead times.

Crystal IS UV LEDs hit 65mW

CThe company's UVC LEDs help to realise ever more increasing range of customer applications including scientific instrumentation and water disinfection

Crystal IS, a manufacturer of proprietary ultraviolet LEDs for monitoring, purification, and disinfection applications, has achieved more than 65mW in optical output at 260 nm from a single UVC LED operated in a continuous mode.

The details of this breakthrough were recently published in *Applied Physics Express*.

"This achievement is a technological milestone in the continued development of brighter, more efficient and reliable UVC LEDs. By employing die thinning and encapsulation techniques, we were able to increase the photon extraction efficiency to over 15 percent," says Leo Schowalter, founder and CTO of Crystal IS.

He adds, "By fabricating our LEDs on our home grown aluminium nitride substrates, we continue to set the pace of what is possible for the combination of highest efficiencies and longest lifetimes in the 250-280 nm wavelength range, far surpassing diodes fabricated on sapphire."

"This R&D accomplishment represents a more than 6-fold increase in performance from just one year ago," adds Larry Felton, CEO. "Our progress in business operations continues on a like pace, readying us and our LEDs for commercial success."

UVC refers to ultraviolet light with wavelengths between 200 - 280 nm. Light in the UVC wavelength can be used for disinfecting water, sterilising surfaces, destroying harmful micro-organisms in food products and in air, and for spectroscopy applications.

Market research analysts Yole Développement estimate that the UVC lamp market to be nearly $200 million in 2012, with lamps being replaced increasingly by UV LEDs.

"Our products will address some of the most pressing health concerns of our time," notes Therese Jordan, Senior Vice President of Business Development. "We are seeing demand in both water and air for the disinfection and quality monitoring aspects of UVC. Similarly, spectroscopic instruments are also taking advantage of the high light output available in a UVC LED. Unlike UV lamps, UVC LEDs are mercury-free, compact, rugged and robust, lending themselves to an array of designs and hold the promise of long life and environmentally friendly end-of-life disposal."

Engineering samples of UVC LEDs are available from Crystal IS.

Long-life gas purifiers for HB-LEDs revealed by Pall

The new purifiers address the need for luminosity and cost control for III-nitride LEDs

Pall Corporation has introduced Gaskleen High-Bright purifiers to remove molecular contaminants from ammonia used in the manufacture of high brightness light emitting diodes (HB-LEDs).

Pall claims the new purifiers will help ensure consistent, cost-effective delivery of the pure ammonia needed to make LEDs with the highest luminosity.

Featuring twice the service life of other commercially available technologies, Gaskleen High-Bright purifiers offer the enhanced performance and cost control that are critical to the economics of LED production.

"With this new purifier, Pall has addressed the industry demand for the brightest LEDs at the lowest operating cost," says Jan-Paul van Maaren, vice president of strategic marketing, Pall Microelectronics. "The cost of LEDs needs to drop and the performance has to rise to accelerate the adoption of LED lamps as replacements for incandescent and CFL bulbs. This new technology will give our customers both a performance and cost advantage."

Gaskleen purifier assemblies combine Pall's proprietary purification materials and Ultramet-L stainless steel filter media. They remove moisture and other oxygenated compounds from process gases to sub ppb levels while providing 3nm or 0.4µm filtration.

What's more, they do not release aluminium or other metal ions into the process stream, further increasing luminosity.

Pall Corporation is a filtration, separation and purification tool manufacturer providing solutions to meet the critical fluid management needs of customers across the broad spectrum of life sciences and industry including semiconductor manufacturers.

Laytec introduces in-situ monitor and software just for PSS

Equipped for wafer bow control, Laytec's latest EpiTT system incorporates a blue laser and triple wavelength reflectance for the precise monitoring of AlN interlayers, AlGaN buffer layers and multiple quantum wells

A major challenge of *in-situ* metrology on single-port reactors with small viewport geometries is the combination of curvature measurements by a blue laser with reflectance measurement at 405nm.

LayTec believes a blue laser is a must for patterned sapphire substrates (PSS) and double-side polished substrates.

Sapphire is a commonly used substrate for LED growth. But it is now coming up against cheaper alternatives such as silicon. However, when it comes to growing compound semiconductors on silicon, the knowledge is still rather lacking.

Which is where the latest LayTec *in-situ* tool could come in useful.

The firm's new version of the EpiCurve TT system, shown in Figure 1 below, is suitable for monitoring the growth of III-nitrides on both silicon and sapphire substrates.

What's more, LayTec says the 405nm reflectance is indispensable for monitoring of InGaN MQW growth. And until now, it was impossible to have both features for reactors with only one small optical access because of the cross-talk effect.

Cross-talk is the capacitive and inductive coupling of signals from one signal line to another. As system performance and board densities increase, so does the problem of cross-talk.

LayTec claims the new optical and electronic design of EpiCurve TT eliminates this problem. The latest version of the tool has been installed on an Aixtron 200-4 RF/S reactor with just a 5mm hole in the ceiling at Otto-von-Guericke University of Magdeburg in Germany.

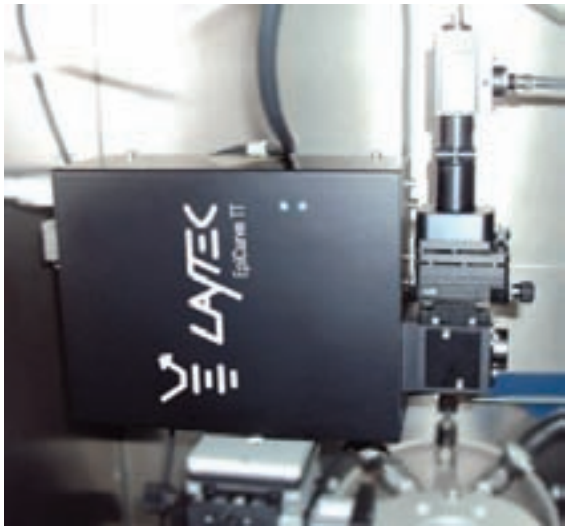


Figure 1: EpiCurve TT used in Magdeburg, Germany

The team of Alois Krost and Armin Dadgar uses the tool in development projects for *in-situ* monitoring of various GaN based optoelectronic and power electronic device structures on silicon and sapphire substrates.

This Epi-Curve TT is equipped with a blue laser (405nm) for wafer bow control and a triple wavelength reflectance (405, 633 and 950nm) for a precise monitoring of MQW layers, AlN interlayers, AlGaN buffer and further features.

After several years of experience with LayTec systems, Krost is convinced that "EpiCurve TT is the best in-situ tool available on the market to control strain, temperature uniformity, MQW formation and surface morphology during III-N device growth.»

In the future, LayTec believes the use of PSS will further increase due to its high light extraction efficiency.

To address this issue, LayTec's *in-situ* metrology software EpiNet 2 can be individually customised for various kinds of PSS. And users can expand the substrate database themselves.

Once the initial reflectance values of the PSS substrates are uploaded, the operator can choose the needed substrate in the RunType's Material Spec window, as depicted in Figure 2. As a result, all PSS wafers can be

monitored with the same accuracy as standard sapphire substrates.

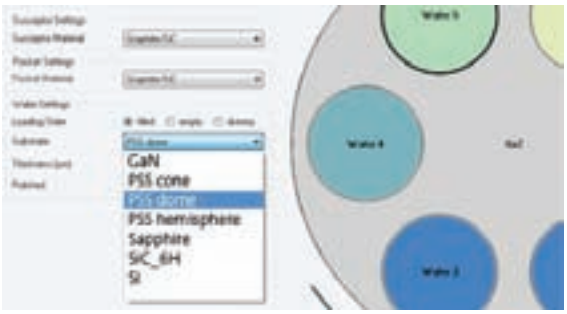


Figure 2: Extract of a Run-Type's Material Spec window of LayTec's EpiNet 2 software with a customised database extended by additional PSS types.

Figure 3 below shows a GaN growth on PSS. The initial 405nm reflectance on the bare PSS substrate is noisy because it senses the local non-uniformity of the PSS structure. As soon as the GaN buffer is thick enough, this noise reduces because the 405nm light does not reach the PSS pattern anymore through the UV absorbing GaN.

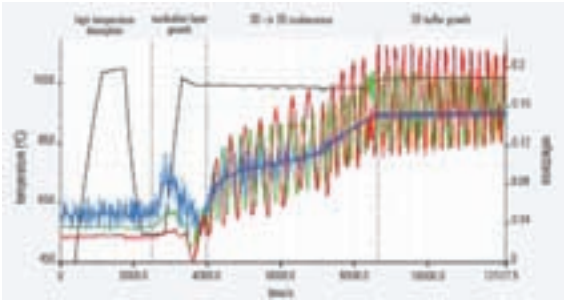


Figure 3: GaN growth on PSS measured by EpiCurve TT at FBH, Berlin, Germany: reflectance at 405 nm (blue), 633 nm (green), 950 nm (red); True Temperature (black).

The increasing reflectance of all 3 wavelengths after ~4000s shows the coalescence process of GaN.

After ~8050s, the 405 nm reflectance stays stable at 15.5 percent, which is an indication of the GaN surface quality improvement. However, the interference patterns of the 633/950nm reflectance look noisy during 2D buffer growth. The initial non-uniformity of the PSS structure causes a certain non-uniformity in the GaN thickness.

Along with the customised database, EpiNet 2 also provides fitting of thin layers, wafer bow calculation and many further features indispensable for growth on PSS.

Samsung`s mid-power LED LM561B package raises the bar

With 160 lumens-per-watt efficacy the module is suited for use in LED tubes, LED ambient lighting, downlighting and retrofit lamps. It provides a 30 percent increase in efficacy compared to Samsung's previous offering

Samsung Electronics has begun producing a new lineup of middle power LED packages with what it claims is the industry's highest efficacy level.

This makes it ideal for use in a wide variety of LED lighting applications including LED tubes, LED ambient lighting, downlighting and retrofit lamps.

Samsung LM561B LED package

The new LM561B features 160lm/W light efficacy, which Samsung says is the highest available among mid-power LED packages worldwide, with electric current rated at 65mA, 5000K CCT (Correlated Colour Temperature), and a rating of over 80 CRI (Colour Rendering Index).

Themodule achieves a 30 percent increase in efficiency compared to Samsung's previous mid-power LED (LM561A) package.

This results in reduced energy consumption and improved heat management. The improved heat dissipation means that smaller heat sinks can be used, saving on material costs, and also provides customers with the ability to create more compact and flexibly innovative products.

"The Samsung LM561B will provide customers with the highest quality of light in the LED package market today, through its high efficacy and variety in colour temperatures," says Jaap Schlejen, senior vice president, LED lighting sales and marketing of Samsung Electronics. "Samsung will continue to improve its product offerings with highly advanced LED package solutions that clearly meet customer needs."

The Samsung LM561B product lineup offers a wide range of colour temperatures. It also comes in three brightness levels and provides quarter binning to allow customers to quickly maximise its use in LED lighting production, free from worries about consistent colour quality or brightness.

Samsung will officially introduce its LM561B family at LIGHTFAIR International 2013 at booth #2645, along with other LED packages, new LED engines, lamps and L-Tubes.

Maximising batch production for HBLEDs with Oxford's tool

The etch solution for GaN, AlGaInP and PSS will offer HBLED production manufacturers high throughput coupled with excellent CoO

Oxford Instruments Plasma Technology has just announced an evolution in batch etch technology with the launch of the PlasmaPro1000 Astrea etch system.

This is a large batch etch solution for PSS, GaN and AlGaInP that will offer HBLED production manufacturers high throughput coupled with industry leading Cost of Ownership (CoO).

PlasmaPro1000 Astrea etch system

The launch is being made at the LED China exhibition in Shanghai this week, where Mark Dineen, Oxford Instruments HBLED Product Manager will present the new system to the LED China Conference delegates.

"The PlasmaPro1000 Astrea is our ultimate batch etch tool, building on over 15 Years experience as a major supplier to the HBLED industry", says Mark Dineen, Oxford Instruments Plasma Technology's HBLED Product Manager, "Today's HBLED manufacturers justifiably demand high yield, high throughput, optimum device quality and low cost of ownership. Our PlasmaPro1000 Astrea large batch etch system offers solutions for all of these."

With wafer batch sizes from 55 x 2" to 3 x 8", the system has been designed specifically for the harsh chemistries required for HBLED materials. Oxford says the PlasmaPro1000 Astrea delivers low damage, high yield processes ensuring the maximum light output from customers' chips.

This highly configurable system, with process chambers that are available as standalone modules or in cluster configurations, available on a four sided cluster tool are capable of supporting up to three process modules.

Designed to ensure high system availability and ease of serviceability, key system features and benefits include over 690mm large area source for highly uniform plasma.

The 490mm electrode is claimed to give unparalleled throughput from batch sizes of 55 x 2", 14 x 4", 7 x 6" and 3 x 8". The tool also has a high conductance pumping system and a dual entry gas inlet for ease of process tuning.

What's more, clamping for wafer cooling is maximised and the system has a *z*-movement electrode for ultimate uniformity. Oxford claims that the reliable hardware and ease of serviceability allows for excellent uptime.

Dan Ayres, Managing Director of Oxford Instruments Plasma Technology comments, "This advanced and innovative system has been developed to address the exacting needs of HBLED Production users, who demand not only the very latest technological innovations, but also the superb customer support offered by our company."

"As an industry leading manufacturer of systems for plasma etch and deposition, Oxford Instruments constantly strives to improve and evolve its systems to provide the ultimate tool. With access to our exclusive library of over 6,000 process recipes, built up over 25 years as a leading plasma tool manufacturer, our customers are guaranteed an excellent product with comprehensive, market leading backup," he concludes.

Yole: UV LED market is booming

Thanks to UV curing, UV LEDs should become a $270 million business by 2017, and could hit $300 million if new applications boom

In its latest report, "UV LEDs: Technology & Application Trends," Yole Développement has described new applications of UV LEDs and associated market metrics for the period 2012-2020.

Thanks to its compactness, low cost of ownership and environmentally-friendly composition, UV LEDs continue to replace incumbent technologies like mercury.

Yole believes the UV LED business to grow from $45 million in 2012 to nearly $270 million by 2017, at a CAGR of 43 percent. In contrast, the traditional UV lamps market is expected to grow at a CAGR of just 10 percent during the same time period.

In 2012, UVA/UVB applications represented 89 percent of the overall UV LED market. Amongst these applications, UV curing is the most dynamic and most important market, due to significant advantages offered over traditional technologies (lower cost of ownership, system miniaturisation, etc.).

This trend is reinforced by the whole supply chain, which is pushing for the technology's adoption: from UV LED module and system manufacturers to ink formulators and the associations created to promote the technology.

And with Heraeus Noblelight's recent acquisition of Fusion UV in January 2013, all major UV curing system manufacturers are now involved in the UV LED technology transition.

Concerning UVC applications, they are still in their infancy and their sales are mainly for R&D purposes and analytic instruments like spectrophotometers. But given some newly published results (increase of EQE over 10 percent, etc.) and the recent commercialisation of the world's first UVC LED-based disinfection system (2012), the market should kick into gear within the next two years.

In addition to traditional applications (UV lamps replacement), and due to their unique properties (compactness, higher lifetime, robustness, etc.), UV LEDs are also creating new applications that aren't accessible to traditional UV lamps, i.e. apps that are miniaturised and portable.

"In 2012, several new UV LED-based products were launched, including cell phone disinfection systems, nail gel curing systems and miniaturised counterfeit money detectors - and this is likely to continue," explains Pars Mukish, Technology & Market Analyst, LED, at Yole Développement.

"We estimate that if new UV LED applications continue emerging, the associated business could represent nearly $30 million by 2017, which would increase the overall UV LED market size to nearly $300 million," he adds.

Once UVC LED performance is sufficient, the supply chain battle will intensify.

The booming UVA/UVB market (mostly UV curing) has attracted several new players from different backgrounds over the past few years: traditional UV lamp suppliers, traditional UV system suppliers, pure UV LED system suppliers, and others.

Each player employs a different strategy for capturing the maximum value created by this disruptive technology: horizontal integration (from UV lamp to UV LED), vertical integration (from UV LED device to UV LED system and vice-versa) or both (from UV lamp to UV LED system).

Yole points out that traditional UV lamp manufacturers are under the most pressure since they have to compensate for the waning lamp replacement market by diversifying their activities in higher supply chain levels.

In the end, every UV LED device/system manufacturer faces the same technical issues when it comes to integrating UV LEDs into a system (thermal management, optics, etc.), but experience is gained with each passing year.

Once UVC LEDs achieve sufficient performance, there's no way a manufacturer will allow the opportunity to pass them by. When that moment comes, the whole supply chain will become a mess due to an increasingly competitive environment, and consolidation will be necessary.

Yole Développement analysis covers the UV LED industry, detailing: main players & associated strategies/ business models, 2012 industrial value & supply chains, key players' revenue and market share, and much more.

AlN on sapphire templates are definitely the substrate of choice for UVA applications, as they provide the right mix between cost and performance. However, for UVC applications (and some UVB applications) the competition with bulk AlN substrate is strong, since such material could allow for improvement at the device level in terms of lifetime, efficiency (IQE and EQE) and power output.

Right now, the debate is still on. And even if bulk AlN's superior performance has been demonstrated by companies such as Crystal-IS and HexaTech, the associated cost (2.5x to 4x more compared to AlN on Sapphire template) still remains an obstacle to developing UVC LEDs are still reasonably priced.

Indeed, such a situation has already occurred with GaN substrate for visible LEDs. Bulk GaN was the ideal technical candidate, but the cost was too high and sapphire was widely adopted instead. Will UV LEDs meet the same fate?

In addition to substrate issues for UVC LED development, epitaxy represents another challenge for increasing device performance. Such barriers will have to be surpassed before we see commercialised UV LED-based disinfection/purification systems.

Telecoms

Mi-Light launches photonics cluster alliance in Michigan

A recent MEDC grant is helping Mi-Light formalise an industry development group

Mi-Light, a newly-established alliance for Michigan's photonics industry, officially launched an organisation with its first Annual Meeting on April 10th, 2013 that included the election and installation of its inaugural board of directors.

The Annual Meeting was preceded by a networking event attended by guests and supporters of Mi-Light including Michael Finney, CEO of MEDC.

In 2012, the Michigan Economic Development Corporation (MEDC) awarded Mi-Light $89,000 to kick-off activities supporting and promoting the growth of the State's photonics industry cluster. Leaders from Michigan photonics companies, many of which are in Washtenaw County, began meeting in 2008 to collaborate on developing Michigan's photonics industry.

"We appreciate the foresight of the MEDC and the State in recognising the important role that Michigan has to play in the global and rapidly-expanding photonics industry," says Mi-Light Chair Michelle Stock. "Industry and educational organisations from across the entire state are participating in Mi-light initiatives that will benefit many dimensions of the state economy."

Mi-Light will use the MEDC funding to promote Michigan's industry and research assets in photonics to a global audience in order to attract companies, talent and new business.

Other aims are to increase awareness of Michigan's breadth and depth of photonics capabilities and assets and develop photonics education and training programs in Michigan to increase the availability of skilled technical personnel at all levels.

Finally, the move should stimulate collaboration among its members and with outside organisations.

Photonics involves innovative applications of lasers, optics, fibre-optics, and electro-optical devices in numerous and diverse fields of technology. Photonics is an enabling technology for nearly every other high-tech industry including telecommunications, controls, energy, defence, manufacturing, research and medicine.

Mi-Light's new board members include: Michelle Stock (mlstock consulting), Chair; David Shindell (Data Optics), Vice-Chair and Acting Treasurer; Anca Sala (Baker College), Secretary; Bodo Ehlers (Rigaku); Sheila Jensen (Visotek); Michael Klos (IPG Photonics); and Richard Kurtz (Advanced Photonix, Inc).

About Mi-Light: Mi-Light is a non-profit organisation serving Michigan's photonics industry by bringing together professionals from companies, academia and organizations to mutually support and promote photonics-related business.

Infinera 100G subsea network spans 38,000km

Using its indium phosphide PIC technology, the firm has deployed its DTN-X technology under water

Infinera 's InP based DTN-X platform with ultra-long haul 500G FlexCoheren super-channel technology is now being deployed in eight subsea networks across approximately 38,000 route kilometres of undersea fibre.

Infinera has publicly announced the DTN-X platform in submarine networks with customers including Telefonica, MedNautilus, PIPE Networks, PACNET and KDDI.

Infinera's solutions have reduced deployment times from months to days while also improving space utilisation by up to 33 percent. Submarine network operators have leveraged this new level of speed and efficiency along with the unique operational efficiency of 500G WDM super-channels enabling them to build subsea networks

faster while driving down total cost of ownership.

Also, Infinera subsea solutions, which are built upon InP photonic integrated circuit technology, are seamlessly integrated with terrestrial networks reducing costs by eliminating equipment and power requirements, while further improving overall network reliability and resiliency.

“There is a significant opportunity for 100G coherent solutions in the long haul subsea market,” says Ron Kline, Principal Analyst Network Infrastructure, Ovum. “100G upgrades for subsea systems are definitely becoming more common, particularly as the financing climate for new cables remains weak and operators can increase capacity by a factor of ten in a short time period compared to constructing a new cable system.”

“Subsea network operators are very discerning customers because they operate mission-critical networks that typically exceed terrestrial specifications,” adds Steve Grubb, Infinera Fellow. “With demand for increased capacity on Submarine routes, the DTN-X, featuring FlexCoherent technology, is delivering submarine operators differentiation in the form of speed and reliability as well as lower total cost of ownership for 100G coherent optical subsea networks. Further, with network resiliency enhancements like Infinera’s FastSMP, network protection not only improves reliability, but also lowers cost.”

The company continues to add capabilities to Infinera’s Submarine Solutions to support network operators. Earlier this year, Infinera conducted a trial with Telstra Global, successfully demonstrating Soft Decision Forward Error Correction (SD-FEC) across a 4,200 km submarine link between Hawaii and California.

Infineon introduces millimetre wave SiGe transceivers

The wireless single-chip ICs simplify the design of small cell backhaul links

Infineon Technologies AG has introduced a new transceiver family that simplifies system design and production logistics by replacing more than 10 discrete devices.

Due to their low power consumption the single-chip high-integration transceivers also help to reduce fixed expenses in high data rate millimetre wave wireless backhaul communication systems. The new transceivers address the market for wireless data links with data rates of more than 1 Gigabit per second (Gbps) between LTE/4G base stations and core networks.

Devices in the Infineon BGTx0 product family come in a standard plastic package and replace more than 10 discrete devices used in current system designs with one single chip. The customers’ assembly process is simplified dramatically as they can continue to use astandard SMT assembly flow.

The BGTx0 family provides a complete radio frequency (RF) front-end for wireless communication in 57-64 GHz, 71-76 GHz, or 81-86 GHz millimetre wave bands. Paired with a baseband/modem, the system solution requires less space, offers improved reliability and lower cost for the critical wireless backhaul links needed in mobile base stations that support LTE/4G networks.

“The V- and E-band microwave frequencies available for LTE/4G backhaul support data rates three times higher than in earlier generation networks. Correspondingly they need superior RF performance to meet operating requirements,” says Philipp von Schierstaedt, Vice President and General Manager of the Business Line RF & Protection Devices at Infineon Technologies.

“With this new transceiver family, Infineon leverages its process technology and RF design leadership to help system designers reduce complexity, simplify their production logistics, and ultimately improve quality and field reliability of their backhaul connectivity solutions.”

The BGTx0 transceivers integrate all of the RF building blocks – I/Q modulator, Voltage Controlled Oscillator (VCO), Power Amplifier (PA), Low Noise Amplifier (LNA), Programmable Gain Amplifier (PGA), SPI control interface and more – on a single chip in a compact, plastic eWLB package (embedded Wafer Level Ball Grid Array). Validation and calibration of RF performance occurs in production using Built-In-Self-Test (BIST), which contributes to the simplicity of integrating the chip into a device builder’s production flow.

The SiGe technology enables deliverable output power of up to 18 dBm of PA, a low noise figure of 6 dB of LNA and excellent VCO phase noise better than -85dBc/Hz at 100kHz offset allows a system designer to implement high modulation schemes up to QAM64 with a sample rate of 500 Msamples/sec and QAM32 with 1Gsamples/sec at a 10 -6 BER (Bit Error Rate).

ESD (Electrostatic Discharge) performance of more than 1KVolt increases the robustness and eases the system design for customers. The low power consumption of less than 2 W for this Backhaul transceiver family also allows network operators to reduce related fixed expenses.

Due to the direct conversion architecture of the transceiver, the interface between RF and baseband is simplified significantly compared to currently available discrete millimeter wave systems.

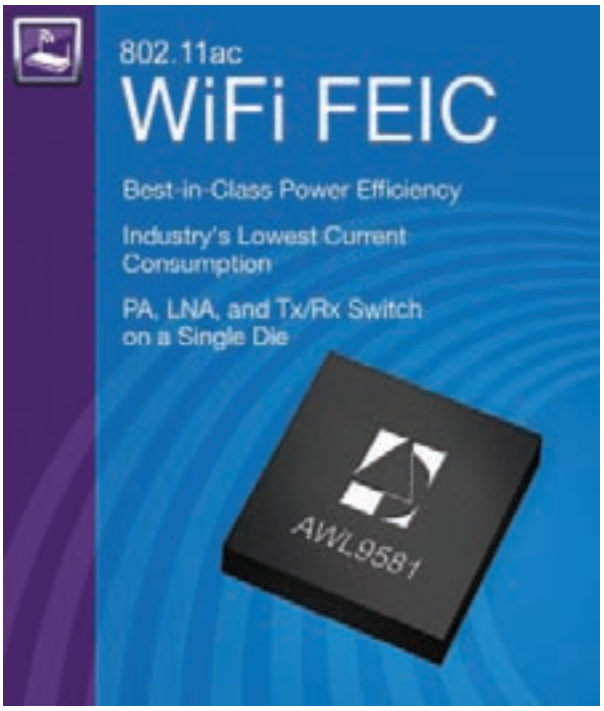
System suppliers also benefit from the quality and reliability of Infineon's automotive qualified production flow for SiGe ICs.

Engineering samples of the BTGx0 family will be available in September 2013, with production ramp planned for late this year.

Murata selects Anadigics` InGaP FEIC for 5GHz WiFi

The 802.11ac module, based on indium gallium phosphide technology, is in mass production to support high-volume mobile applications, including smartphones

Radio Frequency (RF) product provider Anadigics has announced that its AWL9581 front-end integrated circuit (FEIC) is used in Murata's latest WiFi module.



The 2.5 mm x 2.5 mm x 0.4 mm QFN packaged device is now in mass production. This is to support the high demand for smartphones equipped with 802.11ac WiFi technology.

Murata's new WiFi module is optimised for mobile applications by providing complete high-performance WiFi connectivity in a very compact package.

To meet the increasing demand for high-performance WiFi functionality, the wireless mobile device industry is rapidly transitioning to the new IEEE 802.11ac standard. According to Strategy Analytics, 802.11ac will lead WiFi handset sales by 2016.

In support of these trends, Anadigics' AWL9581 enables 802.11ac mobile devices with longer battery-life, greater range, and higher data throughput, while minimising space requirements.

"Anadigics is extremely pleased to be supporting Murata in high-volume production with our most sophisticated 5 GHz front-end IC," says Dave Cresci, vice president of WiFi Products at Anadigics. "The AWL9581 combines a power amplifier, low noise amplifier, and RF switch in a compact, low-profile package. It is a perfect fit for applications that demand highly-integrated, high-performance front-end functionality that is easy to use. With outstanding linearity and noise figure performance, our new 802.11ac FEICs enable maximum throughput and range in mobile devices for an enhanced user experience."

Anadigics' WiFi FEICs provide an combination of integration, efficiency, and linearity to accelerate time to market, increase battery life, and maximise throughput for mobile devices, such as smartphones, tablets, netbooks, notebooks, and gaming systems.

These FEICs use the company's exclusive InGaP-Plus technology and patented design architectures to combine a power amplifier, low-noise amplifier and RF switch on a single die. This level of integration reduces valuable PCB space requirements and simplifies RF front-end design. Anadigics' WiFi FEICs also deliver exceptional error vector magnitude (EVM) and noise figure performance, which enables ultra-high data throughput and connectivity over greater range.

TriQuint reveals three GaAs RF PAs

The gallium arsenide power amplifiers are designed for commercial and defence applications

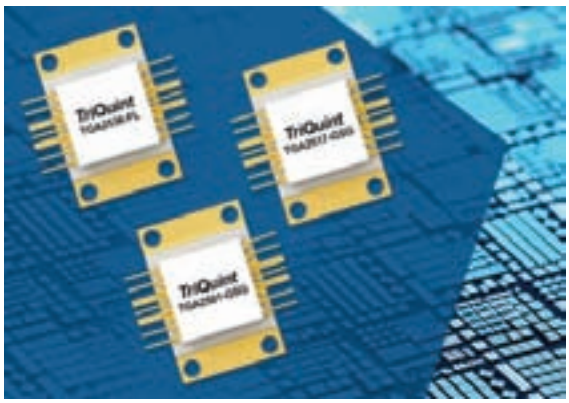
TriQuint Semiconductor has released three new

packaged GaAs RF power amplifiers.

They deliver high output, gain and efficiency for commercial and defence applications including point-to-point microwave radio, radar, VSAT and related applications.

TriQuint's new amplifiers feature low-loss, ground-signal-ground (GSG) RF transitions designed to interface with a coplanar waveguide multilayer PC circuit board for superior grounding.

The packaging enables TriQuint's amplifiers to serve on either side of a PCB board, which facilitates a greater variety of component layout alternatives.



Technical Details:

TGA2501-GSG

3.2W (35dBm), 6-18 GHz RF power amplifier with 26dB small-signal gain, 19dB large-signal gain, 23% efficiency, 8V/1.2A DC bias, integrated DC blocking capacitors, 14-pin 11.38 x 17.32mm flange package.

TGA2536-FL

5.5W (37.4dBm), 13.5-16 GHz RF power amplifier with 25dB small-signal gain, 19dB large-signal gain, 20% efficiency, 8V/2.6A DC bias, integrated DC blocking capacitors, 14-pin 11.38 x 17.32mm flange package.

TGA2517-GSG

14W (41.6dBm), 7.5-11.5 GHz RF power amplifier with 30dB small-signal gain, 22dB large-signal gain, 25% efficiency, 12V/3A DC bias, integrated DC blocking capacitors, 14-pin 11.38 x 17.32mm flange package. ITAR controlled.

Samples and evaluation fixtures are available for all three of the newly released amplifiers.

Xenics and Stemmer extend European IR camera distribution

The companies are boosting the distribution of infrared cameras for industrial automation, machine vision and process control

Xenics, a European provider of advanced infrared detectors, cameras and customised IR imaging solutions, has extended the existing distribution agreement for its industrial IR cameras with Europe's imaging technology provider Stemmer Imaging of Puchheim, Germany.

Xenics IR line camera Lynx-GigE

The new agreement adds Germany and Austria to Stemmer Imaging's distributorship in the UK and France, further broadening its position in the European industrial IR market.

"Our newly extended partnership with Stemmer Imaging is a clear indication to the European market about the excellent image quality and user flexibility of our industrial IR cameras for industrial automation, machine vision and process control. Specifically, this pertains to their small form-factor layout, broad range of lenses availability and industry-standard data interfaces support," says Guido Deutz, Xenics Sales Manager Europe. "The new agreement enlarges the potential for quick and easy imaging systems integration through the proven support of Stemmer Imaging to our German and Austrian customers."

Christof Zollitsch, Managing Director of Stemmer Imaging, adds, "The high-quality infrared cameras offered by Xenics have fully satisfied our quality demands. Based on the positive response from our customers and system partners in the UK and France, our distributing these industrial IR cameras in Germany and Austria will be a very promising widening of our sales and support territories. We see excellent prospects for attractive new application areas of Xenics' leading IR technology."

The Xenics product portfolio included in the distribution partnership with Stemmer Imaging comprises industrial infrared cameras in the visible to short-wave infrared (Bobcat, Cheetah and XS), and long-wave infrared (Gobi). Also included are the industrial versions of Xenics' highly sensitive line-scan cameras (Lynx) in the short-wave infrared realm - one of Xenics' core capabilities.

As presented and introduced at Vision 2012 in Stuttgart, the functional and performing highlights of Xenics cameras - such as Bobcat, Gobi and Lynx - are their standard data interfaces like GigE Vision, CameraLink and, soon to come: CoaXPress. Widespread applications of these advanced industrial cameras are found in food inspection, solar systems testing and electronic component manufacturing.

Xenics founder and CEO Bob Grietens comments on the distribution agreement: "Extending our partnership with Stemmer Imaging in the industrial IR segment will further strengthen the capabilities of our European customers in developing effective and reliable solutions for their specific requirements. I'm convinced that now many more industrial users will utilize the IR spectrum by closely working with a strong technology partner, to the benefit of their own customers."

Christof Zollitsch, General Manager of Stemmer Imaging (left), and Guido Deutz, Xenics Sales Manager Europe (right), after signing the Distributor Partnering Agreement for Germany and Austria

GigOptix takes on Lake Qin as sales director in China

The provider of gallium arsenide (GaAs) and indium phosphide (InP) products is aiming to increase sales revenue in China for all GigOptix product lines

GigOptix, a supplier of advanced semiconductor and optical communications components, has appointed Lake Qin to the role of Director of Sales, China.

Qin, who will be based in Shenzhen, will be responsible for increasing sales revenue in China for all GigOptix product lines.

"I am pleased to welcome Lake to the GigOptix team," says Raluca Dinu, General Manager and Vice President of the Optics and RF Product Line at GigOptix. "Lake brings nearly 15 years of communications experience to GigOptix. Lake is responsible for driving revenue growth in China and will strengthen customer relationships in the region. Lake is supported by our regional applications team and distributors."

Prior to joining GigOptix, Qin held a sales account manager role at Semtech Corporation in Shenzhen. He joined Semtech Corporation through the Gennum Corporation acquisition where he addressed sales in China. In addition, Qin previously held a sales manager role at Lestina International. He begins his role at GigOptix immediately.

GigOptix is a fabless supplier of semiconductor and optical components that enable high speed information streaming that address emerging high growth opportunities in the communications, industrial, defence and avionics industries.

Infinera InP PICs doubleTransBalkan network capacity

The indium phosphide photonic integrated circuits will offer multi-Terabits of capacity and can be used from Greece to Germany; that's more than 8,000 km

Alongside OTEGLOBE, a telecommunications provider in Greece and the Balkans, Infinera has completed the upgrade of OTEGLOBE's international TransBalkan Network (TBN).

The company has deployed 500 Gigabit per second (Gb/s) super channels with the Infinera DTN-X platform.

The InP PIC based platform is being utilised in OTEGLOBE's TransBalkan network which stretches from Greece to Germany across more than 8,000 km and is designed to offer multi-Terabits of capacity.

With this upgrade, OTEGLOBE has doubled the available capacity on this network from 600 Gb/s to more than 1 Terabit per second (Tb/s). This will hopefully meet the telecommunication needs of Europe and the constantly increasing demand in the regions of Middle East and Africa.

At the same time, OTEGLOBE's network is able to support 10 Gb/s, 40 Gb/s and 100 Gb/s services to its customers, international carriers, fixed and mobile operators, and multi-site organisations.

Infinera's DTN-X platform combines 500 Gb/s long haul super-channels with 5Tb/s of integrated OTN switching capacity enabling OTEGLOBE to offer highly scalable, efficient and reliable services.

The platform also provides an intelligent, standardised GMPLS control plane for high-speed restoration.

"We have been working with Infinera since 2008 using the DTN platform in our TBN network," states Panagiota Bosdogianni, OTEGLOBE's Technology Director. "During the past 4 years we took advantage of Infinera's solution for its flexibility, reliability and ease of use, allowing us to activate new 10 Gb/s services in minutes. Being satisfied with our Infinera experience we selected the new DTN-X platform for our recent network upgrade, which has been successfully completed without disturbing existing traffic or our network operation procedures."

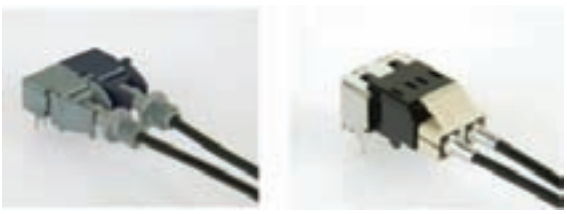
"Infinera is committed to delivering the most reliable and latest technology to our customers without the expense of conventional network architectures," continues Chris Champion, VP EMEA Sales. "We are excited that OTEGLOBE has deployed the Infinera DTN-X platform for their international network, bringing improved reliability to global carriers in the region."

Firecomms & Leoni to enhance fibre optic LED transceivers

The agreement between the two companies should enable customer supply chains to benefit from alternative fibre optic transceiver sources

Firecomms has teamed up with Leoni to offer its LED transceivers as an alternative to existing market-dominant systems.

Firecomms will collaborate with the Business Unit Fibre Optics of the Leoni Group to develop its RedLink LED-based fibre optic products. The devices have the option of coming with an LC connector and a connector interface that is compatible with Avago Technologies Versatile Link interface.



Firecomms RedLink transceiver and LC connector

"By collaborating with Firecomms, we can profitably combine the competences of both our companies," says Andreas Weinert, Vice President of the Business Unit Fibre Optics of the Leoni Group.

"As a result, we can offer our clients coordinated system solutions with optimised interaction of Polymer Optical (POF) and Polymer Cladded Fibre (PCF) cables, connectors, assemblies and special solutions in fibre optical technologies. Our goal is to give interested industrial companies the opportunity to qualify an alternative source of supply in order to enhance the security and flexibility of their supply chain."

Available in mid-2013, Firecomms RedLink series will include DC-1 Mb, DC-5 Mb, DC-10 Mb and DC-50 Mb transceivers with an operating temperature ranging from -40° to 85° C.

"The increasing market demand has motivated us to provide our clients a higher degree of freedom in their supply chain," adds Hugh Hennessy, Vice President Sales & Marketing of Firecomms Ltd.

"We welcome the cooperation with Leoni Fibre Optics, who can complement our product offering with their expertise as a leading supplier of optical fibres, cables and assemblies. The synergy of our RedLink with Leoni's FiberConnect product lines offers clear cost-benefit advantages for our clients."

The Business Unit Fibre Optics of the Leoni Group is one of the leading suppliers of fibre optical technology for special applications in industry, sensor technology and analytics as well as in science, communication and laser medicine.

The Business Unit Fibre Optics offers a unique product range at every stage of the value chain: from preforms and drawn fibres to fibre optic cables and complete fibre optic systems with in-house developed optical components for use in industrial, medical and telecommunication appliances.

The company has sites in Europe, America and Asia with production and support.

NeoPhotonics acquires Lapis Semiconductor's optical business

The indium phosphide expert is adding capabilities for data rates of 100G and above and will expand its PIC integration. The acquisition will also strengthen the firm's profile in Japan and provide entry in to the high speed IC

market

InP PIC specialist NeoPhotonics has finalised its acquisition of the semiconductor optical components business unit (OCU) of Lapis Semiconductor Co., Ltd.

Lapis designs and manufactures high speed lasers, laser drivers, photodiodes and amplifiers for high speed networks.

OCU was previously the component division of OKI Electric for high speed lasers and high speed III-V amplifiers before it was acquired by Rohm Semiconductor in 2008. The OCU business was merged into and now operates as NeoPhotonics Semiconductor GK, a Japanese subsidiary of NeoPhotonics.

Neophotonics specialises in manufacturing InP and silica-on-silicon photonic integrated circuit (PIC) based modules.

"We are pleased to have closed the previously announced acquisition of the optical components unit of Lapis Semiconductor in accordance with our purchase agreement and earlier than planned," says Tim Jenks, Chairman and CEO of NeoPhotonics.

"We look forward to this expansion of our 100G product suite, our further strategic expansion into the Japan market, the addition of new global network equipment and module customers, and expanding our business opportunities with our current mutual customers."

On March 29th, 2013, NeoPhotonics paid approximately $10.2 million in cash for the business of OCU, after adjustments, and approximately $3.7 million in cash as the first of four equal payments for the associated real estate.

In the transaction, NeoPhotonics also assumed employee retirement obligations of approximately $6.5 million and compensation obligations of approximately $0.6 million. The total consideration for the real estate including the payment was approximately $14.6 million with the balance payable over the next three years.

Including the future payments for real estate, the total purchase price amounted to approximately $35.2 million. The purchase consideration was based on the Japanese Yen.

On March 21st, 2013, NeoPhotonics entered into a syndicated Revolving Credit and Term Loan Agreement with Comerica Bank, as administrative agent and lead arranger. East West Bank has also become a lender under this facility.

NeoPhotonics borrowed $28 million under the term loan facility and $12 million under the revolving credit facility to refinance existing company indebtedness of approximately $20.9 million and help finance the OCU acquisition and related transaction expenses.

Anticipated OCU Financial Impact

Based on preliminary unaudited pro forma financial information provided by the management of Lapis Semiconductor, OCU had revenue of approximately $45 million for the first nine months ended September 30th, 2012.

NeoPhotonics plans to provide an update on the OCU business, now NeoPhotonics Semiconductor GK, when it releases its quarterly financial results for the first quarter of 2013, which is currently expected to be in the first half of May 2013. The company is also preparing the required historical and pro forma financial results reflecting the acquisition and plans to file the information with the Securities and Exchange Commission within the next 75 days, or by June 12th, 2013.

TowerJazz and Avago expand SiGe collaboration

The companies aim to focus on Avago's next-generation products using TowerJazz's SiGe BiCMOS technology platform

An extended collaboration between Avago and TowerJazz will enable Avago Fibre Optic Products Division (FOPD) to achieve the stringent technical specifications and meet cost and performance requirements for optical networking markets.

It will also help TowerJazz to define and develop its next-generation process technologies.

The collaboration has previously resulted in Avago's recent successful launch of the Gen4SR product, a 10Gbps small form factor pluggable optical transceiver (SFP) for short reach applications.

Avago will gain unlimited access to TowerJazz's SiGe BiCMOS technology based on both the SBC18H2 process with transistor speeds of 200GHz and H3 process with transistor speeds of 280GHz together with mixed-signal CMOS.

"TowerJazz's advanced technology enables Avago Technologies to define and develop a plethora of new products, increasing our market share with existing and new customers. Avago's 10Gbps SFP+ chipset is the first product released deploying TowerJazz's technology,"

says Faouzi Chaahoub, Senior Director of R&D, IC Engineering Fibre Optic Products Division (FOPD) Avago Technologies.

He continues, "Our collaboration with TowerJazz using their high performance SiGe BICMOS will enable us to develop the highest performance and the lowest power ICs for Avago's next generation optical transceivers beyond 10Gbps."

"We are fortunate to have a technology partner such as Avago FOPD who continually pushes the technology envelope and drives TowerJazz to excellence," adds Marco Racanelli, Senior Vice President & General Manager of RF/High Performance Analogue Business Unit.

"Our high performance SiGe is uniquely positioned in the fibre optic space where we offer customers the highest speed, lowest power consumption and lowest noise SiGe transistors integrated in analogue-friendly 0.18µm and 0.13µm nodes."

Infinera's unique SMP solution to revolutionise communication

The indium phosphide based telecom provider is now offering a hardware acceleration chip that enables recovery from multiple-failures in less than 50 milliseconds

Infinera has developed the "FastSMP", a next generation network protection solution designed for the firm's DTN-X platform.

The DTN-X platform is based on the company's InP PIC (Photonic Integrated Circuit) technology.

It offers providers increased network resiliency with protection against multiple failures while lowering the total cost of ownership.

With FastSMP, Infinera says it is delivering the industry's only hardware-based Shared Mesh Protection (SMP) solution based on the FastSMP processor, a hardware acceleration chip that enables recovery from multiple-failures in less than 50 milliseconds (ms).

This hardware chip is pre-installed on the DTN-X and can be enabled via a simple software upgrade ensuring complete investment protection for customers building their networks with the DTN-X.

Infinera has shipped more than 2,000 100G ports to date and every port shipped is ready to be upgraded to FastSMP.

"Current approaches to network resiliency are inadequate to meet the rapidly evolving network performance and cost requirements of service providers," says Michael Kennedy, Principal Analyst at ACG Research. "SMP utilises the best attributes of 1+1 protection and MPLS FRR for operators to offer a range of new services with multi-tiered protection levels. We found up to 33 percent lower total cost of ownership for SMP as compared with 1+1 protection."

With FastSMP network operators can offer sub 50ms protected services like 1+1 protection but with higher availability and reduced costs.

Since it utilises the digital transport layer it provides better network economics than packet-based solutions and recovers from local as well as remote failures across thousands of nodes within 50ms offering better protection than MPLS Fast Re-Route in many scenarios.

"Pacnet's unique position is its ability to offer true long haul submarine mesh architecture on its core network within the APAC region," says Andy Lumsden, Pacnet Chief Technology Officer. "Our selection of the DTN-X has provided new levels of scale for our network allowing us to accommodate customer traffic and deliver high capacity services faster than our competitors. The combination of the Infinera DTN-X platform and its hardware-accelerated FastSMP approach will provide Pacnet with a combination of resiliency, capacity and flexibility needed to meet the highest demands of our customers."

"Infinera is committed to being the leader in transport networking innovation," continues Dave Welch, Co-founder, EVP, and Chief Strategy Officer Infinera. "Infinera has revolutionised the industry with the DTN-X delivering 500G super-channels based on large scale photonic integrated circuits. Now Infinera FastSMP offers a solution that offers a more resilient mesh network, protecting our customers' services and lowering total network cost."

FastSMP is based on the emerging industry standard Shared Mesh Protection that allows transport networks to recover from multiple local and network-wide failures without the need to dedicate backup bandwidth for every active circuit. Infinera has filed patents for its hardware-accelerated FastSMP and is expected to start delivering multi-failure protection and restoration capabilities in 2013.

First mass-produced SiC module without a Schottky diode

Japanese firm Rohm has reduced power loss in its new silicon carbide device, making it ideal for 1200V/180A inverters

Rohm has started mass-production of a 1200V/180A-rated SiC MOS module BSM180D12P2C101 for inverters/converters used in industrial equipment, photovoltaic power conditioners and the like.

BSM180D12P2C101

The firm says this new module is the first to incorporate a power semiconductor comprised of just a SiC MOSFET, increasing the rated current to 180A for broader applicability while contributing to lower power consumption and greater compactness.

Next-generation SiC MOSFET technology minimises conduction degradation of the body diode, eliminating the need for diode rectification. This makes it possible to increase the mounting area for higher current handling capability while maintaining the same compact form factor.

What's more, by improving processes and device structures related to crystal defects Rohm was able to overcome all problems related to reliability, including that of the body diode.

Switching characteristics are maintained using a simple MOS structure without a Schottky Barrier Diode. And unlike silicon IGBTs used in general-purpose inverters, no tail current is generated, reducing loss by more than 50 percent.

Also, switching frequencies over 50kHz are supported, which Rohm says is impossible with silicon IGBTs. This contributes to smaller, lighter peripheral devices.

General-purpose silicon IGBT devices are not capable of conduction in the reverse direction.

In contrast, the body diode in Rohm's SiC MOSFET always conducts in reverse. And depending on the Gate signal input the MOSFET can operate in either direction for lower ON resistance or using just the diode. These reverse direction conduction characteristics enable a high efficiency synchronous rectification in the 1000V range - higher than diode rectification.

Another positive is that clarifying the mechanism by which defects are spread based on body diode conduction makes it possible to minimise the primary factors through process and device construction.

With general-purpose products the ON resistance increases significantly after 20 hours. In contrast, Rohm says its new module ensures no ON resistance increases - even after more than 1000 hours.

Avago speeds up networking with 150G and 168G modules

The devices incorporate a GaAs 850nm VCSEL transmitter and III-V PIN receiver. The firm claims the modules have the industry's highest aggregate bandwidth per module which maximises the delivery of 12.5G and 14G data channels for next-generation networks

Avago Technologies has introduced four new sets of Atlas Optical Engine 12-channel parallel optics transmitter and receiver modules.

These are the 12.5G and 14G MiniPOD modules and the 12.5G and 14G MicroPOD modules.

The devices are designed to maximise the delivery of 12x12.5Gbps and 12x14Gbps embedded optical solutions targeting high density backplane and midplane applications for next-generation Ethernet, Optical Transport Networking (OTN), Infiniband and high-speed interconnects.

All four modules have a GaAs based 850nm VCSEL array in transmission mode and a III-V PIN array in receiving mode.

Avago MiniPOD module

Avago MicroPOD module

Avago›s 12x12.5G solutions include the MiniPOD AFBR-812VxyZ/AFBR-822VxyZ and MicroPOD AFBR-77D2SZ/AFBR-78D2SZ. The data rate agnostic for both modules supports 1G to 12.5G and is compatible with 12xQDR Infiniband. The devices support a link distance of up to 100m.

The firm›s 12x14G products are the MiniPOD AFBR-814VxyZ/AFBR-824VxyZ and the MicroPOD AFBR-77D4SZ/AFBR-78D4SZ. In this case, the data rate agnostics support 1G to 14G and both modules are compatible with 12xFDR Infiniband. The link distance for these devices support up to 50m.

“The introduction of the 12.5G and 14G MicroPOD and MiniPOD embedded optics solutions demonstrates Avago’s continued technology leadership in parallel optics, enabling customers to go beyond the standard 100G solutions by maximising system bandwidth, channel density and power efficiency in their systems,” says Philip Gadd, vice president and general manager of the Fibre Optics Product Division at Avago.

Samples of the AFBR-812VxyZ/AFBR-822VxyZ and AFBR-814VxyZ/AFBR-824VxyZ are available in the MiniPOD package, and samples of the AFBR-77D2SZ/AFBR-78D2SZ and AFBR-77D4SZ/AFBR-78D4SZ are available in the MicroPOD package.

RFMD to dispose of Newton Aycliffe UK GaAs facility

The company expects to phase out manufacturing in its Newton Aycliffe, UK-based GaAs pHEMT facility and transition most GaAs manufacturing to its GaAs HBT manufacturing facility in North Carolina

RF Micro Devices, a designer and manufacture of high-performance radio frequency solutions, has announced a new GaAs sourcing strategy intended to increase manufacturing flexibility, expand gross margin, and support aggressive growth.

RFMD will phase out manufacturing in its Newton Aycliffe, UK-based GaAs pHEMT facility and transition most GaAs manufacturing to its GaAs HBT manufacturing facility in Greensboro, North Carolina.

RFMD will also partner with leading GaAs HBT foundries for additional capacity. The Newton Aycliffe GaAs pHEMT facility had been RFMD’s primary source for cellular switches, which RFMD has transitioned to higher performance, lower cost silicon on insulator (SOI).

The transition will occur over the next nine to 12 months to support existing millimetre wave customer contracts. Once implemented, RFMD expects annual cost savings of approximately $20 million, or $5 million per quarter.

Bob Bruggeworth, president and CEO of RFMD, says, “RFMD is enjoying increasing demand for our GaAs- and silicon-based RF solutions by delivering the industry’s highest performance and most innovative products and technologies, including power amplifiers, switches, antenna tuners, and envelope tracking solutions.”

Bruggeworth adds, “The combination of our industry-leading internal GaAs manufacturing capabilities and our external GaAs and silicon foundry partnerships support our longstanding commitment to Optimum Technology Matching, satisfy the full breadth of our customers’ performance, size, and cost requirements, and give RFMD unlimited growth potential. We expect these structural changes to have a lasting positive effect on the company’s cost structure, resulting in meaningful gross margin expansion.”

RFMD is actively seeking a buyer for the Newton Aycliffe facility. If a buyer cannot be found, the facility will be closed once contractual obligations are met.

New SiGe amplifiers for optical markets from TriQuint

The new transimpedance silicon germanium amplifiers can support 40G, 100G and emerging optical systems

TriQuint Semiconductor has expanded its optical infrastructure portfolio with five new transimpedance amplifiers (TIAs).

They will enable the company to serve both transmit and receive portions of high performance optical networks.

The new product family complements TriQuint's modulator driver portfolio for 10, 40, 100 Gb/s and next-generation 200G/400G systems.

TriQuint's new TIAs offer performance benefits tailored to key design requirements that support 40G, 100G and emerging optical systems. TriQuint's new products are part of a recent technology acquisition from Micram Microelectronic GmbH.

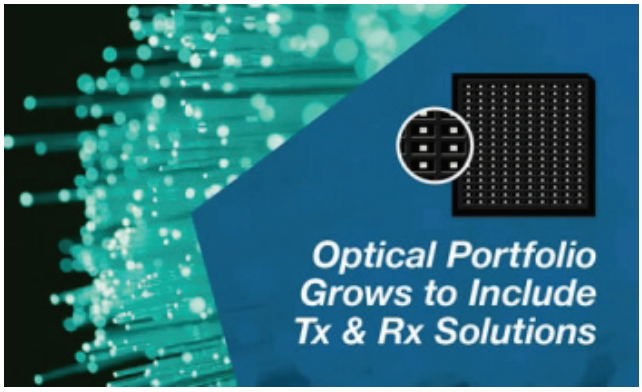
"This new amplifier family perfectly complements our optical modulator drivers. We're sampling next-generation products and receiving positive feedback from numerous customers," says James L. Klein, TriQuint Vice President and General Manager for Infrastructure and Defence Products. "Our new TIA family serves today's fastest networks as well as the higher modulation needs of future optical broadband systems."

The continual worldwide growth in smartphone and tablet data traffic as well as other broadband mobile devices is driving global network capacity expansion. Optical networks remain the most economical means for long-distance, high-speed data transfers across wired and mobile device networks. Infonetics Research commented recently that the global optical market is expected to grow in 2013, with expansion primarily in North America, China, Europe and the Middle East.

"Our conversations with equipment providers continue to trend positive, particularly in North America where 100G spending is about to ramp up... Meanwhile, there are positive rumbles in the EMEA region; preliminary results show that 2013 will be a huge year for 100G in China; China is about half of the global 40G WDM market," notes Infonetics Principal Optical Analyst, Andrew Schmitt, in a February 2013 report.

TriQuint's first TIA release includes five new SiGe amplifiers for use in optical networks ranging from very-short-reach to metro- and long-haul. The company's optical experts will be showcasing its products at booth #2127.

TriQuint's new TIAs, the TGA4864, TGA4861, TGA4866, TIA56 and TIA56A, offer a broad array of on-chip benefits; samples are available; contact product marketing for details.



Technical Details:

TGA4864
Dual differential 100 Gb/s SiGe TIA in die form with manual or automatic gain control for metro- or long-haul coherent PM-QPSK networks. Less than 1 percent THD at 350mVpp output, tuneable frequency response from 24-32 GHz, 26dB dynamic range, single +3.3V supply, peak level detection, output shutdown function, OIF intradyne receiver MSA compliant.

TGA4861
Dual differential 40 Gb/s SiGe TIA in die form with manual or automatic gain control for metro- or long-haul coherent DP-QPSK networks. Less than 1 percent total harmonic distortion (THD) at 350mVpp output, tuneable frequency response of 8.5-13.5 GHz, 26dB dynamic range, single +3.3V supply, peak level detection, optional input strength indicator, output shutdown function, OIF intradyne receiver MSA compliant.

TGA4866
Single-ended input, differential output 40 Gb/s SiGe limiting TIA in die form for very-short-reach networks using SONET OC-768, SDH STM-256 or 44.6 Gb/s Ethernet (IEEE-802.3b). Input noise density is 15pA/√Hz and differential transimpedance gain of 2.8KΩ, optical overload resistance up to +6dBm, tuneable frequency response from 34-38 GHz, automatic or manual threshold adjustment, single +3.3V supply.

TIA56
40 Gb/s SiGe TIA in die form for metro or long-haul DPSK networks. Allows differential or single-ended input or output up to 800mVpp, frequency response tuneable from 20 to 35 GHz, 30pA/√Hz noise density, 4.5KΩ differential transimpedance, DC and AC coupled, output eye adjustment pin, single -5.2V supply.

TIA56A
40 Gb/s SiGe TIA in die form for metro or long-haul

DPSK networks. Allows differential or single-ended input or output, 600mVpp differential and 300mVpp single-ended output, frequency response tuneable from 20-35 GHz, 30pA/√Hz noise density, 4.5KΩ differential transimpedance, DC and AC coupled, output eye adjustment pin, peak level detection, single -5.2V supply.

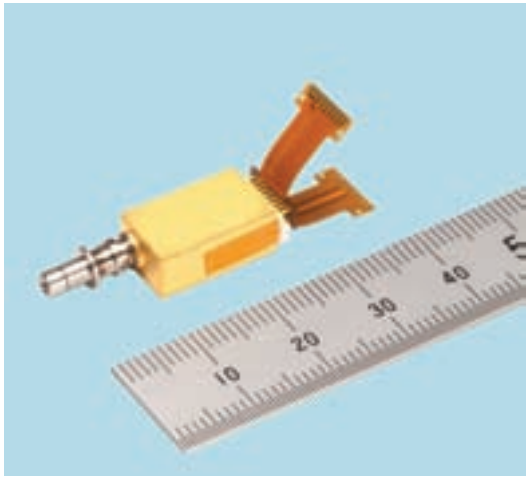
Mitsubishi Electric to launch miniature 40Gbps driver

The EML-TOSA device will help to downsize facilities and expand high-speed 40Gbps optical transmission networks

Mitsubishi Electric Corporation will begin shipping a compact 40Gbps electro-absorption modulator with Laser diode-Transmitter Optical Sub Assembly (EML-TOSA) for optical transmissions on June 1st 2013.

As of March 1st, the FU-695REA became the world's first EML-TOSA to comply with the 40Gbps Miniature Device Multi-Source Agreement (XLMD2-MSA). This standard was signed by Mitsubishi Electric, LAPIS Semiconductor, Oclaro, Renesas Electronics and Sumitomo Electric Industries, and was made effective on March 13th.

The common specifications for a compact EML-TOSA based on the XLMD2-MSA, aim to meet the demand for smaller equipment and thereby expand the market for 40Gbps EML-TOSA.



40Gbps driver-in EML-TOSA, "FU-695REA"

As 10Gbps optical network interfaces give way to faster 40Gbps interfaces, installations in confined spaces are requiring the use of smaller communication equipment, which led to the demand for a downsized EML-TOSA.

Mitsubishi Electric says it will be the world's first optical device manufacturer to ship an XLMD2-MSA-compliant EML-TOSA for optical transmissions, thereby helping to downsize 40Gbps communication facilities and expand high-speed 40Gbps optical transmission networks.

The device is claimed to facilitate the design of optical transceivers and the common-specification device sizes and optical/electrical interfaces allow manufacturers to standardise transceiver designs.

Compared to other comparable modules, the FU-695REA is claimed to have a less expensive electrical interconnection with flexible printed circuit board instead of coaxial connectors.

Contributing to the miniaturisation of optical transceivers, the device is claimed to be 50 percent smaller than the existing FU-697SEA model.

Also, the package size of 9.2mm x 18.1mm x 5.7mm (excluding the receptacle), complies with common specifications for small CFP2/CFP4 optical-transceiver modules.

The 1.55μm device has a maximum transmission distance of 2km and an output power of 0 to 3dBm. The RF input signal is based on a flexible printed circuit with differential signal interface.

micro-ITLA for coherent transport launched by Neophotonics

The firm's new micro-ITLA is designed to offer improved performance for next generation coherent networks for 100 Gbps and beyond

Manufacturer of photonic integrated circuits, NeoPhotonics Corporation has announced a small form factor, narrow-linewidth, micro-Integrated Tuneable Laser Assembly (also known as micro-ITLA technology.)

This next generation of laser is designed to reduce the footprint by more than a factor of three and reduce power consumption compared to current generation ITLAs.

The micro-ITLA is also intended to outperform current generation narrow-linewidth lasers in both linewidth and output optical power.

This micro-ITLA utilises NeoPhotonics InP PIC technology, which allows the integration of many active and passive photonic functions within single chip elements. The NeoPhotonics micro-ITLA is designed to

be compliant to the Optical Internetworking Forum (OIF) implementation agreement.

The demand for bandwidth continues to grow at a rapid pace. Deployments of 100 Gbps networks utilising advanced modulation techniques and coherent detection are increasingly preferred by carriers as these technologies provide improved signal quality and allow for longer spans in metro and long-haul "backbone" networks; thus lowering the overall cost of transporting high-bandwidth data from one place to another.

The narrow-linewidth tuneable laser is a key element in coherent optical communications systems. Much like tuning to a signal in a radio receiver, coherent detection uses a narrow-linewidth laser (local oscillator) tuned to the transmitter optical frequency. Laser linewidth must be in the range of a few hundred kilohertz to avoid penalties to signal-to-noise ratio and system performance.

"NeoPhotonics is one the few companies that can design and manufacture precision tuneable lasers with linewidth suitably narrow for coherent network applications. In fact, we became the industry's largest supplier of narrow-linewidth tuneable lasers in 2012," boasts Tim Jenks, Chairman and CEO of NeoPhotonics. "In the micro-ITLA we utilise our PIC technology to minimise the device size and power consumption, while providing our customers with the device performance and production capabilities they need to capture the growth that is apparent in the 100G market space."

NeoPhotonics unveils colourless receiver for 100G optical networks

VICR, which incorporates InP (indium phosphide), is designed to improve signal-to-noise ratio and increase coincident channel count in 100G coherent systems

NeoPhotonics Corporation has launched a new 100G variable power intradyne coherent receiver (VICR).

The photonic integrated circuit (PIC)-based VICR integrates a variable optical attenuator (VOA) on the signal path and is designed to increase dynamic range and improve the optical signal to noise ratio (OSNR) for both single channel and multiple coincident signals.

This capability is designed to enable service providers to better manage network capacity in colourless coherent networks.

NeoPhotonics is currently sampling the VICR and expects to enter general availability with this product in the second half of 2013.

Core networks are rapidly moving towards more efficient "colourless" operation, meaning that ROADM add and drop ports are not limited to fixed predetermined wavelength channels. Instead, a tuneable transmitter can connect any wavelength to any add port and the ROADM can route any wavelength to any drop port receiver.

Colourless operation improves the efficiency of valuable line cards and transponders in coherent transport networks, where a single DWDM channel carries 100Gbps of information.

In coherent optical communications systems the coluorless channel drop operation is enabled by using the local oscillator laser and the VICR to select the receive channel, eliminating the need for a terminal optical filter.

The VICR then detects the signal channel to which the local oscillator laser is matched, but all other channels are outside the device bandwidth. In colourless applications the remaining channels are not filtered out optically, so the incoming signal power to the VICR can vary significantly depending on how many other channels are present, resulting in up to 100 times higher power falling on the receiver than in the single channel case.

The NeoPhotonics VICR integrates a PIC variable optical attenuator that provides control and stability to the input signal. In both colourless and conventional optically filtered systems, the VOA also improves performance by allowing system selection of the optimal operating point to enhance OSNR and reduce the effects of optical impairments such as polarisation dependent loss (PDL).

"We are pleased to add the VICR to our extensive line of PIC based intradyne coherent receivers," says Tim Jenks, Chairman and CEO of NeoPhotonics. "The VICR illustrates the power of photonic integration to provide additional functionality to our existing products, which are designed to benefit our customers with improved performance in the same form factor and simplified board layouts."

In addition, NeoPhotonics personnel are participating in a workshop and a panel devoted to PON access applications and presenting a paper on ROADM-based wavelength agility:

OneChip forges InP based partnerships with IQE & GCS

Foundry Global Communication Semiconductors will provide the Canadian based firm with a complete range of indium phosphide wafer processing services. OneChip will also use IQE's epitaxial growth services to produce its InP PICs for the data centre interconnect and passive optical network markets

OneChip Photonics is working with Global Communication Semiconductors (GCS), an ISO-certified premier pure-play compound semiconductor wafer foundry.

GCS is providing a broad range of InP wafer processing services to OneChip. The firm will use these InP wafers to produce its Photonic Integrated Circuits (PICs) for the Data Centre Interconnect (DCI) and Passive Optical Network (PON) markets.

OneChip's unique, regrowth-free, Multi-Guide Vertical Integration (MGVI) platform eliminates the need for multiple epitaxial growth steps. This enables OneChip to decouple epitaxial growth and wafer processing, while outsourcing both functions to independent, pure-play commercial foundries.

Under this fabless model, OneChip has been working with GCS to process its OneChip-designed 4-inch InP-based wafers. This leverages the infrastructure and expertise GCS has gained through serving high-volume radio frequency (RF) electronics markets.

GCS's foundry services, based on its Opto and Heterojunction Bipolar Transistor (HBT) processes in InP, are a perfect match to OneChip's fabless model, which is built around its regrowth-free PIC platform.

What's more, GCS's Opto and HBT and OneChip's PIC technologies share the same process and provide a unique Opto-Electronic Integrated Circuit (OEIC) platform. This, for the first time, enables both electronic and photonic integration on one substrate, within the same commercially available fabrication process.

Valery Tolstikhin, Founder and CTO of OneChip Photonics, says, "GCS is the most advanced, pure-play foundry of its kind, which offers Indium Phosphide and high-volume RF electronics processing technologies. Working with GCS gives us the commercial, high-volume processing capability we need to meet the strict cost requirements of the DCI and PON markets."

Brian Ann, CEO of GCS, adds, "Our InP-based Opto and RFIC process technologies have great synergies with OneChip's PIC technology. We believe OneChip is a company that can create a truly volume business for photonics in the DCI market, with the unique ability to combine PICs and electronics to create the first optoelectronic circuits in InP."

OneChip's regrowth-free, PIC-based InP technology has proven successful in the very cost-sensitive, high-volume PON market, as OneChip's PIC-based PON transceivers and Bi-directional Optical Sub-Assemblies (BOSAs) already are being deployed by the world's largest PON system providers.

Now, OneChip is extending this technology to the high-volume DCI market. This market requires 100Gbps+ solutions with higher interface density and longer reach than those within the reach of currently deployed systems in 0.85μm and multi-mode fibres.

The DCI market also requires lower cost and power consumption than the solutions offered by the traditional telecom component vendors.

GCS is an ISO 9001:2008 certified premier pure-play Compound Semiconductor foundry located 15 miles south of Los Angeles International Airport. GCS's business goal is to supply high performance, high quality, specialty semiconductor devices, integrated circuits and solutions to the wireless, telecommunications and fibre optical communications markets.

In a second collaboration, OneChip is also working with Cardiff based IQE to produce high-volume InP PICs. The company will use IQE's epitaxial growth services to produce its InP PICs for the DCI and PON markets.

Under this fabless model, OneChip has been working with IQE for the production of its OneChip-designed 4-inch indium phosphide (InP)-based epitaxial wafers. This leverages the infrastructure and expertise IQE has gained over 25 years, supporting the advanced semiconductor industry with its pioneering outsourcing model.

Valery Tolstikhin, Founder and CTO of OneChip Photonics, comments, "The iron-doped, semi-insulating 4-inch InP substrates, and the MOCVD growth technique, required for OneChip's epi-wafers, are the same as those used by IQE for its high-volume epitaxy products, so we have strong economies of scale in working together. IQE is recognised as a leading independent, pure-play epi-wafer foundry, which not only provides world-class services, but also perfectly fits into our fabless PIC manufacturing model."

Drew Nelson, President & CEO of IQE, adds, "OneChip has developed some exciting new integrated photonics products for the high-volume, but cost-sensitive, optical communications markets. We are delighted to apply our

unique high-volume manufacturing expertise in producing InP-based epi-wafers for OneChip's innovative PIC technology. OneChip's use of the fabless manufacturing approach further endorses IQE's outsourcing business model in the field of photonic devices, and we look forward to helping OneChip continue to scale its business as it extends its unique PIC technology to new markets."

OneChip's InP PICs trounce silicon and VCSEL technologies

The firm's fully integrated indium phosphide devices prevent the complicated steps required by CMOS silicon and VCSEL processess

OneChip Photonics has launched a new family of Photonic Integrated Circuit (PIC)-based 100Gbps (gigabits per second) optical interconnects.

They will enable transceiver manufacturers to produce high-speed, low-power and small-size modules for Data Centre Interconnect (DCI) applications.

OneChip's fully integrated 100Gbps solutions provide a myriad of advantages over solutions based on silicon photonics, discrete components and vertical cavity surface emitting lasers (VCSELs).

This new family of 100Gbps solutions builds on the PIC-based receiver chips that OneChip previously announced, and made available for partner testing, in 2012.

Jim Hjartarson, CEO of OneChip Photonics, says, "OneChip can provide transceiver and system manufacturers with the integrated solutions that they need to meet their cost, power, size and speed requirements, without all of the problems inherent with silicon photonics solutions."

Vladimir Kozlov, Founder and CEO of LightCounting, a leading optical communications market research company, adds, "Integration of optics and electronics on one chip holds strong promise for providing low power, cost-effective 100Gbps interface modules for data centre applications. These attributes will be important in this high-volume market. In fact, this market is only going to be high volume if low power and low cost products are available."

According to LightCounting, 100 Gigabit Ethernet transceiver sales are expected to grow from $144 million in 2012 to almost $700 million in 2017 (at 36 percent CAGR).

Integrated Solutions are Needed to Meet Cost, Power & Size Requirements in the Data Centre

System integrators want to drive costs down to the point where 100Gbps solutions are as cost-effective to implement as 10Gbps solutions are today. Currently, 100GBASE-LR4 implementations are far too expensive to be useful in data centre interconnect applications.

What's more, transceiver providers want to fit 100Gbps solutions into QSFP (Quad Small Form factor Pluggable) modules, as QSFPs represent the smallest form factor for packaged transceivers, but they must dissipate only 3.5 watts of power or less.

The only way to meet the cost, power and size requirements, for DCI applications, is through tightly integrated chipsets and sub-assemblies. This is where OneChip's breakthrough PIC technology comes in.

OneChip monolithically integrates all of the optical functions required for an optical transceiver into a single InP-based chip. All of the active components (Distributed Feedback "DFB" laser, Electro-Absorption Modulator "EAM," and Waveguide Photodetector "WPD") and passive components (Wavelength Division Multiplexing "WDM" combiner, splitter and Spot-Size Converter "SSC") of the chip are, uniquely, integrated in one epitaxial growth step - without re-growth or post-growth modification of the epitaxial material.

These Multi-Guide Vertical Integration (MGVI)-based PICs enable numerous cost, power and size advantages over competing solutions based on silicon photonics, discrete components and VCSELs.

Why InP PIC-based 100Gbps Solutions Are Better Than Solutions based on Silicon Photonics, Discrete Components and VCSELs

Because silicon cannot lase and also detect in the required spectral range (1300nm), silicon photonics providers must add materials which can, for example, bond III-V semiconductors (for lasing) or epitaxially overgrow germanium (for detection) on top of silicon.

Thus, silicon photonics chips cannot be manufactured simply by using standard CMOS (Complementary Metal Oxide Semiconductor) materials and processes. This also makes adding photonics capability to advanced sub-micron silicon process nodes cost prohibitive. These inherent drawbacks prevent silicon photonics solutions from achieving the cost and size requirements - and the ability to manufacture in volume through standard electronics foundries - needed in Data Centre Interconnect applications.

By contrast, OneChip's single-growth MGVI platform eliminates the need for multiple epitaxial regrowth steps, in which material from the previous growth step(s) that is selectively etched out must be replaced with another material regrowth step(s).

Consequently, OneChip can partner with standard, high-volume InP electronics foundries to fabricate its PIC-based solutions, which improves economies of scale. The firm already has relationships with IQE and Global Communication Semiconductors (GCS).

Also, OneChip's MGVI platform in InP is based on the same process that inherently produces the best and fastest Heterojunction Bipolar Transistors (HBTs) used in Radio Frequency Integrated Circuits (RFICs).

As such, the company also will be able to integrate electronics, such as Transimpedance Amplifiers (TIAs) and modulator drivers, within a commercially available and volume-scalable process. The silicon photonics dream of leveraging high-volume electronic chip production, while combining photonics and electronics onto the same substrate, is ironically best realised in InP.

All of these advantages hold true when comparing OneChip's 100Gbps solutions with solutions based on discrete components and VCSELs, as well.

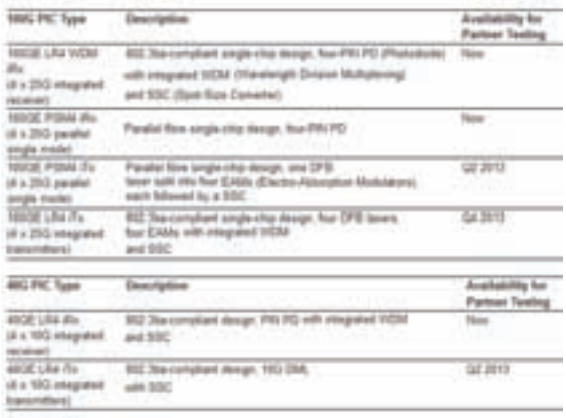
The inherent drawbacks of VCSEL-based solutions, for example, are that they cannot accommodate Wavelength Division Multiplexing (WDM), are difficult to couple with single mode fibres, and become expensive when made to address long-wavelength interconnect applications.

OneChip's InP-based PIC technology enables it to multiplex multiple lasers together and produce chip and module solutions that support standard communications wavelengths - for example, in the 1310nm window - very cost effectively.

The company's regrowth-free, PIC-based InP technology has proven successful in the very cost-sensitive, high-volume Passive Optical Network (PON) market, as OneChip's PIC-based PON transceivers and Bi-directional Optical Sub-Assemblies (BOSAs) already are being deployed by the world's largest PON system providers.

Now, OneChip is extending its technology to the high-volume DCI market. This market requires 100Gbps+ solutions with higher interface density and longer reach than those based on VCSELs and multi-mode fibres. The DCI market also requires lower cost and power consumption than the solutions offered by the traditional telecom component vendors.

The new family of 100Gbps Data Centre Interconnect PICs includes the following. This chart also references the 40Gbps DCI PICs that OneChip announced previously.



OneChip is currently working with partners to optimally package these 100G and 40G PICs for specific applications.

The firm is also developing PIC-based 100GE PSM4 TROSAs (Transmitter-Receiver Optical Sub-Assemblies) for DCI applications.

Fraunhofer IAF chooses Veeco GEN200 MBE system

The tool will be used for research and development of various antimonide and arsenide-based III-V optoelectronic devices

The Fraunhofer Institute for Applied Solid State Physics IAF, an institution specialising in the field of compound semiconductor research in Freiburg, Germany, has purchased a Veeco MBE GEN200 reactor.

According to Martin Walther, Head of Infrared Detectors Business Unit at Fraunhofer IAF, "We have been working with Veeco for more than a decade, and have had very good experiences with the existing Veeco MBE systems in our facility. Thus we decided in favour of Veeco's fully automated production MBE systems as demand for epitaxial layers for antimonide based III-V optoelectronics has increased."

Jim Northup, Vice President, General Manager of Veeco's MBE Operations, adds, "This new purchase extends our longstanding collaborative relationship with Fraunhofer IAF, one of the world's top research facilities in the field of III-V semiconductors. Our GEN200 is known for its lowest cost 4 x 4" epiwafer growth and it is the ideal tool to support Fraunhofer IAF's expansion in growth services."

The GEN200 is a cost-effective and highest capacity multi - 4" production MBE system. It is claimed to deliver superior throughput, long campaigns and excellent wafer quality in growing GaAs or InP-based wafers for such devices as pump lasers, VCSELs and HBTs.

Oclaro revolutionises InP tuneable transmitters

The firm has developed an indium phosphide device for 100G coherent CFP2. The module enables a new generation of pluggable devices for metro and long-haul markets

Oclaro has achieved a key milestone towards the development of a 100G coherent CFP2 pluggable module based on a new generation of InP photonic components.

The firm says the devices can deliver the high density, low power dissipation, and reduced cost that customers need in order to drive coherent technology into next generation metro and long-haul markets.

Being able to bring 100G coherent transmission technology into a pluggable form factor has long been considered a far-fetched target because of the challenges associated with power dissipation, performance, and size.

Oclaro's recent achievements in its high-volume InP technology have now put this goal within reach. As part of its development program, Oclaro was able to demonstrate that its transmitter can achieve the high electro-optic bandwidth and low power dissipation to meet the requirements of an analogue coherent CFP2.

The integrated 100G transmitter replaces two discrete narrow linewidth tuneable lasers (typically external cavity iTLAs), and an external Mach-Zehnder modulator with a single component that serves as both the transmitter and as the local oscillator for the coherent receiver.

Combined with Oclaro's InP-based micro coherent receiver and its high speed electronics expertise, the company is now in a position to bring a coherent CFP2 pluggable module to market.

"With this accomplishment, Oclaro has reaffirmed its leadership position in indium phosphide technology and is now in an excellent position to deliver a new generation of highly disruptive pluggable modules for coherent applications," says Jim Haynes, President of Global Business for Oclaro, Inc.

He adds, "We are excited that Oclaro will enable its customers to drive the growth of coherent technology into the metro and long haul markets where higher density and lower power dissipation are critical requirements and where pluggability offers significant benefits."

Oclaro will be providing demonstration units of its InP photonic components to customers throughout 2013. The coherent CFP2 production ramp is expected for mid-2014.

The development of the coherent CFP2 module represents a major step forward for the industry, offering customers significant advantages associated with density, cost and power dissipation.

The CFP2 module allows customers to replace two discrete tuneable lasers (iTLAs), an external Mach-Zehnder modulator and a coherent receiver with a single pluggable module that enables a pay-as-you-grow strategy where 100G channels can be provisioned as required.

The integrated 100G transmitter features a narrow line-width tuneable laser co-packaged with a dual QPSK InP Mach-Zehnder modulator with two optical output fibres: one for the transmit path and one to serve as the local oscillator in the receiver.

The micro coherent receiver is a highly compact device incorporating InP optical hybrids, dual balanced waveguide photo-detectors and transimpedance amplifiers (TIA's) to provide the correct electrical output.

TriQuint touts GaN Ku-band PA and integrated broadband amps

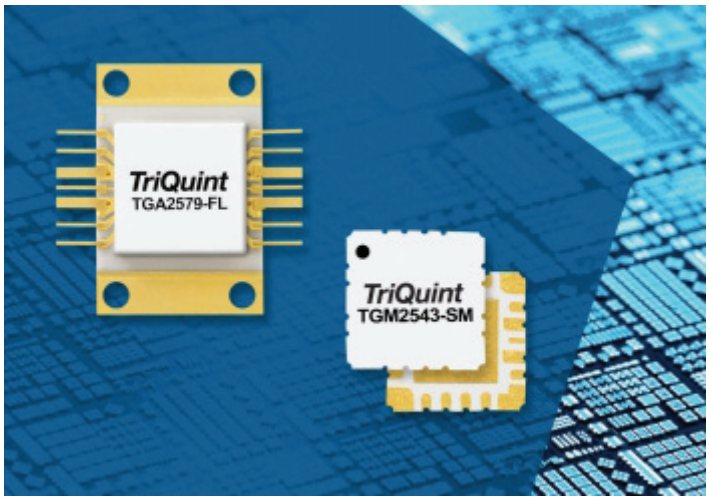
The gallium nitride amplifiers deliver performance and versatility for commercial and defence systems

TriQuint Semiconductor has released a novel broadband integrated packaged solution.

The device combines a limiter with a low-noise amplifier (LNA) for use in radar and electronic warfare along with a 25W Ku-band GaN RF power amplifier for satellite communications.

TriQuint's new 25W TGA2579-FL power amplifier (PA) is placed in a ground-signal ground package. This means it can be mounted on the top or underside of multi-layer circuit boards, giving designers the greatest possible flexibility. It provides 25W of saturated output power with 30 percent power added efficiency.

This 13.75-15.35GHz GaN RF PA has +48dBm Output Third Order Intercept Point (OIP3), 32dB small-signal gain and ground-signal-ground RF transitions for interfacing with coplanar waveguide circuit boards. With a 25V/1A DC bias, the TGA2579-FL comes in a 14-pin SMT package.



The TGA2543-SM's high gain and extremely wide operating bandwidth (4-20 GHz) provides broad versatility. It integrates limiting and LNA functions in a single package. Robust protection of sensitive receiver circuits and low-noise amplification are achieved in less space with fewer devices. The TGA2543-SM's hermetically-sealed, 22-lead 7x7mm ceramic surface mount QFN package meets MIL-STD 883H TM 1014.13 condition, A1/C1.

The device has RF input limiting of 4W CW (+36dBm), +17dBm mid-band gain, a 2dB noise figure, +28dBm (OIP3), adjustable gain control and a 5V/100mA DC bias.

TriQuint's Near Junction Thermal Transport (NJTT) GaN program was honoured in March with a 2013 CS Industry Award.

TriQuint says its NJTT initiative has produced the industry's first GaN-on-diamond HEMT transistors that significantly reduce heat while maintaining RF performance. TriQuint innovation can enable RF devices up to three times smaller than those currently available. This award is TriQuint's third consecutive honour for GaN research from international semiconductor industry leaders.

James L. Klein, Vice President and General Manager for Infrastructure and Defense Products, remarks that TriQuint's efforts are unlocking the true potential of GaN. "We are enabling new generations of GaN devices that offer significant RF design and operational benefits for our commercial and defence customers," he says. TriQuint's design-ready GaN solutions are complemented by a full range of post-processing, packaging, test and foundry services.

The TGA2579-FL and TGM2543-SM are in production; samples and evaluation boards are available.

RF Electronics

RFMD recruits Qualcomm veteran as VP of foundry services

James A. Clifford has vast experience in manufacturing, engineering and procurement

RF Micro Devices has taken on James A. Clifford as Vice President of its Foundry Services unit.

Clifford has wide-ranging experience in technology, procurement, supply chain, operations, quality, and program management.

From 1994 until 2012, Clifford served at Qualcomm Corporation, most recently as Senior Vice President and General Manager Operations. Prior to this, he spent 21 years at Unisys Corporation, in multiple positions of increasing responsibility covering manufacturing, engineering and procurement.

In his newly created position at RFMD, Clifford will report to James D. Stilson, Corporate Vice President of Operations, with responsibility for RFMD's relationships with external foundry partners. Clifford will be based in RFMD's headquarters, located in Greensboro, North Carolina.

Bob Bruggeworth, president and CEO of RFMD, says, "We are very pleased to welcome Jim to RFMD as vice president, Foundry Services. Jim is extremely well respected throughout the technology industry, and we are delighted he is joining our team. Given Jim's broad knowledge of all areas of the semiconductor industry, we expect him to contribute immediately to our ability to deliver the industry's highest performance and most innovative technologies and RF solutions."

James Clifford holds a BS in Physics from San Diego State University.

Nitronex appoints new Engineering VP

The GaN (gallium nitride) power device RF designer and manufacturer for the defence, communications, broadband, and industrial & scientific markets is to diversify

Nitronex has named David W. Runton as its new Vice President of Engineering.

Runton has almost 20 years of RF power semiconductor experience with six years in GaN specific product development, including design, assembly, qualification and packaging.

“I’m looking forward to working with the engineering team to develop many new successful GaN products. Nitronex has very compelling technology that I feel has advantages for numerous market applications,” says David Runton. “I am joining Nitronex at an exciting time with a new owner, management team, and significant growth plans for the future.”

Runton most recently served as Director of High Power Engineering for RFMD where he led an engineering product release team and developed long term product strategy. He has also held engineering leadership positions at Freescale and Motorola Semiconductor.

“David is an excellent addition to our management team and I’m confident he will help us leverage our core technology in the RF power market. He has an extensive background developing LDMOS and GaN power devices and a proven track record leading engineering teams to develop new products and technologies,” says Greg Baker, President and CEO.

Runton holds a Bachelor Degree and a Master of Science degree in Electrical Engineering from the Georgia Institute of Technology and a Masters in Business Administration, High Technology Program from Arizona State University.

TriQuint announces inducement equity grants

The grant was undertaken under NASDAQ Marketplace Rule 5635

The Compensation Committee of TriQuint’s Board of Directors approved a stock option award for an aggregate of 150,000 shares of the company’s common stock under the company’s 2008 Inducement Award Program to one new employee.

The stock option grant was effective March 7th, 2013.

The options will vest 25 percent on March 7th, 2014 with the remaining 75 percent vesting quarterly over the next three years, and have an exercise price of $4.58, which was the closing price of TriQuint’s common stock on March 7th, 2013. The option grant expires on March 7th, 2023.

TriQuint’s Compensation Committee, which is solely comprised of independent directors, approved the grant of the stock options on February 13th, 2013 in accordance with NASDAQ Listing Standard 5635(c)(4).

Lasers

Hamamatsu reveals lasers for gas monitoring

Hamamatsu Photonics has produced a series of quantum cascade lasers (QCLs), offering both continuous and pulsed output in the mid-infrared region, at room temperature

Hamamatsu’s latest technology fabricates different QCLs with emission wavelengths tailored from 4.8μm to 10.6μm.

The current lineup already features high output power at room temperature, typically 10 to 50 mW, with a very narrow spectral line width of 0.02 nm. The emission wavelength of the QCL can be altered with accurate control of the operating temperature and stabilised emission is Fabry Perotor Distributed Feed Back laser structure, depending on the customer’s requirements. The current lineup includes lasers in both HHL and TO-8 packages and there are a range of accessories available. These include; forced air and water cooled laser mounts, pulsed QCL drivers as well as ZnSe lenses and lens adaptors. There are many emerging applications for QCLs including high-resolution spectroscopy systems for environmental sensing and pollution monitoring, breath analysis in medical diagnosis, industrial process control and security applications such as screening for plastic explosives.

Xenics and Stemmer extend European IR camera distribution

The companies are boosting the distribution of infrared cameras for industrial automation, machine vision and process control

Xenics, a European provider of advanced infrared detectors, cameras and customised IR imaging solutions, has extended the existing distribution agreement for its industrial IR cameras with Europe's imaging technology provider Stemmer Imaging of Puchheim, Germany.

Xenics IR line camera Lynx-GigE

The new agreement adds Germany and Austria to Stemmer Imaging's distributorship in the UK and France, further broadening its position in the European industrial IR market.

"Our newly extended partnership with Stemmer Imaging is a clear indication to the European market about the excellent image quality and user flexibility of our industrial IR cameras for industrial automation, machine vision and process control. Specifically, this pertains to their small form-factor layout, broad range of lenses availability and industry-standard data interfaces support," says Guido Deutz, Xenics Sales Manager Europe. "The new agreement enlarges the potential for quick and easy imaging systems integration through the proven support of Stemmer Imaging to our German and Austrian customers."

Christof Zollitsch, Managing Director of Stemmer Imaging, adds, "The high-quality infrared cameras offered by Xenics have fully satisfied our quality demands. Based on the positive response from our customers and system partners in the UK and France, our distributing these industrial IR cameras in Germany and Austria will be a very promising widening of our sales and support territories. We see excellent prospects for attractive new application areas of Xenics' leading IR technology."

The Xenics product portfolio included in the distribution partnership with Stemmer Imaging comprises industrial infrared cameras in the visible to short-wave infrared (Bobcat, Cheetah and XS), and long-wave infrared (Gobi). Also included are the industrial versions of Xenics' highly sensitive line-scan cameras (Lynx) in the short-wave infrared realm - one of Xenics' core capabilities.

As presented and introduced at Vision 2012 in Stuttgart, the functional and performing highlights of Xenics cameras - such as Bobcat, Gobi and Lynx - are their standard data interfaces like GigE Vision, CameraLink and, soon to come: CoaXPress. Widespread applications of these advanced industrial cameras are found in food inspection, solar systems testing and electronic component manufacturing.

Xenics founder and CEO Bob Grietens comments on the distribution agreement: "Extending our partnership with Stemmer Imaging in the industrial IR segment will further strengthen the capabilities of our European customers in developing effective and reliable solutions for their specific requirements. I'm convinced that now many more industrial users will utilize the IR spectrum by closely working with a strong technology partner, to the benefit of their own customers."

Christof Zollitsch, General Manager of Stemmer Imaging (left), and Guido Deutz, Xenics Sales Manager Europe (right), after signing the Distributor Partnering Agreement for Germany and Austria

ProPhotonix to distribute more Oclaro laser products

Oclaro has added its high-power laser products to the ProPhotonix range

ProPhotonix Limited is now distributing Oclaro's line of

high-power lasers in North America and Europe.

Examples of Oclaro's lasers

Oclaro's high power lasers complement ProPhotonix's low power laser diodes and laser modules used in markets such as medical, defence and security, and instrumentation.

The new products will also enable ProPhotonix to address a wider set of applications including materials, processing and printing.

ProPhotonix is already a major distributor of Oclaro's Visible and near IR laser diodes.

Oclaro manufactures high power lasers with many packaging options for the industrial and consumer markets.

Adding these solutions will offer ProPhotonix customers a comprehensive solution set for their applications and enable the company to grow revenues in markets which have so far been unavailable with its existing products.

Commenting on the distribution agreement, Mark W. Blodgett, Chairman and CEO of ProPhotonix says, "This new product line gives our customers the opportunity to work with one vendor on their critical applications, which has significant cost and time saving implications. We are already widely known for our engineering expertise, manufacturing and support within the laser and LED community. Adding these high powered laser products to our distribution channels extends the number of customers able to leverage those resources."

Blodgett continues, "ProPhotonix continues to build a strong reputation as a world leader in innovative laser and LED solutions. Strengthening our partnership with Oclaro not only extends that position, but also gives our customers the benefit of Oclaro's extensive experience in laser manufacturing and fibre optic coupling. Customers can now take advantage of both our strengths."

Gunnar Stolze, Vice President, Oclaro, Global Sales Industrial & Consumer, adds, "We are pleased to be expanding our business relationship with ProPhotonix. Given their recent expansion of technical sales teams in both the US and Europe, ProPhotonix is well positioned to increase sales of our product portfolio for industrial and consumer markets, including high power laser devices."

Aixtron supports LED and laser research at Peking University

The institute has purchased another reactor (3 by 2 inch) to grow aluminium gallium nitride (AlGaN) based products

China's Peking University has ordered another Aixtron MOCVD reactor.

The Close Coupled Showerhead (CCS) reactor has a capacity for three 2-inch (3 x 2") substrates in a single run.

The order was made in the second quarter of 2012 with delivery scheduled for the first quarter of 2013.

Aixtron Close Coupled Showerhead (CCS) Reactor

One of the researchers who will be using the Aixtron system is Shen Bo. He says, "We already have an Aixtron CCS system in use, and we are very satisfied with it. We now needed a system to improve our UV LED and laser research. The aluminium gallium nitride (AlGaN) material growth needed for this is very challenging due to the very high temperatures of more than 1200°C required. Also AlGaN is very difficult to dope, particularly with magnesium that is used to create the *p*-type regions needed for hole injection."

Aixtron's Close Coupled Showerhead (CCS) concept is suited for small scale production and R&D. Processes are easily scaleable to larger systems. Aixtron says the stable platform comes with excellent reliability, ease of use and reproducibility.

Founded in 1898, Peking University (PKU) was the first national comprehensive university in China. At the end of the 20th century, the Chinese government placed PKU at the top of the agenda for promoting higher education, with a view to making it a world-class university by the 21st century.

Supported by the government, Peking University has made great progress in cross-disciplinary programming, talent nurturing and scientific research.

Green lasers could be a hazard

A NIST investigation has reported that almost 90 percent of green and about 44 percent of red pointers were out of compliance with federal safety regulations

With a low-cost apparatus designed to quickly and accurately measure the properties of handheld laser devices, National Institute of Standards and Technology (NIST) researchers tested 122 laser pointers.

They found that nearly 90 percent of green pointers (around 532nm) and about 44 percent of red pointers tested were out of compliance with federal safety regulations.

The NIST test apparatus was designed so that it can be replicated easily by other institutions.

NIST laser safety officer Joshua Hadler with his apparatus for measuring the properties of handheld laser devices.

As NIST researchers reported at a conference on March 20th, 2013, both red and green laser pointers often emitted more visible power than allowed under the Code of Federal Regulations (CFR), and green pointers often emitted unacceptable levels of infrared light as well.

Anecdotal reports of green laser hazards have previously appeared in scientific journals and the media, but the new NIST tests are the first reported precision measurements of a large number of handheld laser devices.

The NIST tests point out that many red laser pointers are also, unexpectedly, out of compliance with federal regulations. "Our results raise numerous safety questions regarding laser pointers and their use," the new paper states.

The NIST tests were conducted on randomly selected commercial laser devices labelled as Class IIIa or 3R and sold as suitable for demonstration use in classrooms and other public spaces. Such lasers are limited under the CFR to 5 milliwatts maximum emission in the visible portion of the spectrum and less than 2 milliwatts in the infrared portion of the spectrum.

About half the devices tested emitted power levels at least twice the CFR limit at one or more wavelengths. The highest measured power output was 66.5 milliwatts, more than 10 times the legal limit. The power measurements were accurate to within 5 percent.

According to the American National Standards Institute (ANSI), laser devices that exceed 3R limits may be hazardous and should be subject to more rigorous controls such as training, to prevent injury.

Green lasers generate green light from infrared light. Ideally, the device should be designed and manufactured to confine the infrared light within the laser housing. However, according to the new NIST results, more than 75 percent of the devices tested emitted infrared light in excess of the CFR limit.

NIST Laser Safety Officer Joshua Hadler designed the measurement test bed.

The system consists of a laser power meter and two optical filters to quantify the emissions of different wavelengths of visible and infrared light. The power meter and filters were calibrated at NIST. Lens holders ensure repeatable laser alignment, and an adjustable aperture contains the laser light around the output end of the laser.

"The measurement system is designed so that anyone can build it using off-the-shelf parts for about $2,000," Hadler says. "By relying on manufacturers' traceability to a national measurement institute such as NIST, someone

could use this design to accurately measure power from a laser pointer."

Avago speeds up networking with 150G and 168G modules

The devices incorporate a GaAs 850nm VCSEL transmitter and III-V PIN receiver. The firm claims the modules have the industry's highest aggregate bandwidth per module which maximises the delivery of 12.5G and 14G data channels for next-generation networks

Avago Technologies has introduced four new sets of Atlas Optical Engine 12-channel parallel optics transmitter and receiver modules.

These are the 12.5G and 14G MiniPOD modules and the 12.5G and 14G MicroPOD modules.

The devices are designed to maximise the delivery of 12x12.5Gbps and 12x14Gbps embedded optical solutions targeting high density backplane and midplane applications for next-generation Ethernet, Optical Transport Networking (OTN), Infiniband and high-speed interconnects.

All four modules have a GaAs based 850nm VCSEL array in transmission mode and a III-V PIN array in receiving mode.

Avago MiniPOD module *Avago MicroPOD module*

Avago›s 12x12.5G solutions include the MiniPOD AFBR-812VxyZ/AFBR-822VxyZ and MicroPOD AFBR-77D2SZ/AFBR-78D2SZ. The data rate agnostic for both modules supports 1G to 12.5G and is compatible with 12xQDR Infiniband. The devices support a link distance of up to 100m.

The firm›s 12x14G products are the MiniPOD AFBR-814VxyZ/AFBR-824VxyZ and the MicroPOD AFBR-77D4SZ/AFBR-78D4SZ. In this case, the data rate agnostics support 1G to 14G and both modules are compatible with 12xFDR Infiniband. The link distance for these devices support up to 50m.

"The introduction of the 12.5G and 14G MicroPOD and MiniPOD embedded optics solutions demonstrates Avago's continued technology leadership in parallel optics, enabling customers to go beyond the standard 100G solutions by maximising system bandwidth, channel density and power efficiency in their systems," says Philip Gadd, vice president and general manager of the Fibre Optics Product Division at Avago.

Samples of the AFBR-812VxyZ/AFBR-822VxyZ and AFBR-814VxyZ/AFBR-824VxyZ are available in the MiniPOD package, and samples of the AFBR-77D2SZ/AFBR-78D2SZ and AFBR-77D4SZ/AFBR-78D4SZ are available in the MicroPOD package.

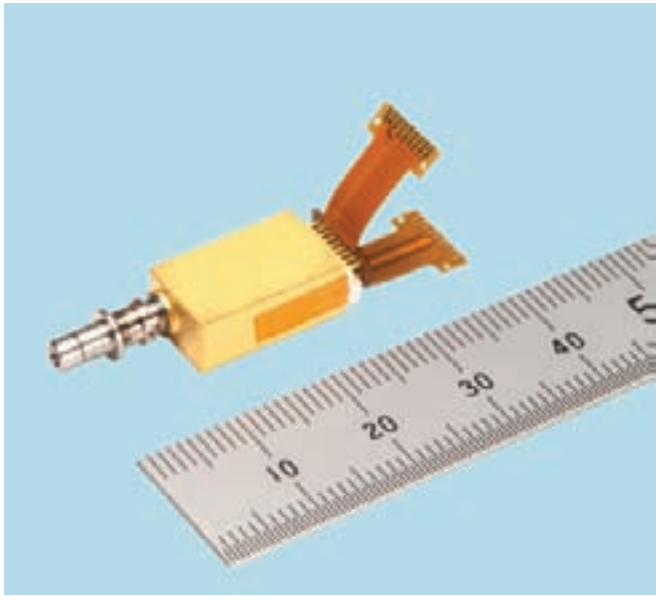
Mitsubishi Electric to launch miniature 40Gbps driver

The EML-TOSA device will help to downsize facilities and expand high-speed 40Gbps optical transmission networks

Mitsubishi Electric Corporation will begin shipping a compact 40Gbps electro-absorption modulator with Laser diode-Transmitter Optical Sub Assembly (EML-TOSA) for optical transmissions on June 1st 2013.

As of March 1st, the FU-695REA became the world's first EML-TOSA to comply with the 40Gbps Miniature Device Multi-Source Agreement (XLMD2-MSA). This standard was signed by Mitsubishi Electric, LAPIS Semiconductor, Oclaro, Renesas Electronics and Sumitomo Electric Industries, and was made effective on March 13th.

The common specifications for a compact EML-TOSA based on the XLMD2-MSA, aim to meet the demand for smaller equipment and thereby expand the market for 40Gbps EML-TOSA.



40Gbps driver-in EML-TOSA, "FU-695REA"

As 10Gbps optical network interfaces give way to faster 40Gbps interfaces, installations in confined spaces are requiring the use of smaller communication equipment, which led to the demand for a downsized EML-TOSA.

Mitsubishi Electric says it will be the world's first optical device manufacturer to ship an XLMD2-MSA-compliant EML-TOSA for optical transmissions, thereby helping to downsize 40Gbps communication facilities and expand high-speed 40Gbps optical transmission networks.

The device is claimed to facilitate the design of optical transceivers and the common-specification device sizes and optical/electrical interfaces allow manufacturers to standardise transceiver designs.

Compared to other comparable modules, the FU-695REA is claimed to have a less expensive electrical interconnection with flexible printed circuit board instead of coaxial connectors.

Contributing to the miniaturisation of optical transceivers, the device is claimed to be 50 percent smaller than the existing FU-697SEA model.

Also, the package size of 9.2mm x 18.1mm x 5.7mm (excluding the receptacle), complies with common specifications for small CFP2/CFP4 optical-transceiver modules.

The 1.55μm device has a maximum transmission distance of 2km and an output power of 0 to 3dBm. The RF input signal is based on a flexible printed circuit with differential signal interface.

micro-ITLA for coherent transport launched by Neophotonics

The firm's new micro-ITLA is designed to offer improved performance for next generation coherent networks for 100 Gbps and beyond

Manufacturer of photonic integrated circuits, NeoPhotonics Corporation has announced a small form factor, narrow-linewidth, micro-Integrated Tuneable Laser Assembly (also known as micro-ITLA technology.)

This next generation of laser is designed to reduce the footprint by more than a factor of three and reduce power consumption compared to current generation ITLAs.

The micro-ITLA is also intended to outperform current generation narrow-linewidth lasers in both linewidth and output optical power.

This micro-ITLA utilises NeoPhotonics InP PIC technology, which allows the integration of many active and passive photonic functions within single chip elements. The NeoPhotonics micro-ITLA is designed to be compliant to the Optical Internetworking Forum (OIF) implementation agreement.

The demand for bandwidth continues to grow at a rapid pace. Deployments of 100 Gbps networks utilising advanced modulation techniques and coherent detection are increasingly preferred by carriers as these technologies provide improved signal quality and allow for longer spans in metro and long-haul "backbone" networks; thus lowering the overall cost of transporting high-bandwidth data from one place to another.

The narrow-linewidth tuneable laser is a key element in coherent optical communications systems. Much like tuning to a signal in a radio receiver, coherent detection uses a narrow-linewidth laser (local oscillator) tuned to the transmitter optical frequency. Laser linewidth must be in the range of a few hundred kilohertz to avoid penalties to signal-to-noise ratio and system performance.

"NeoPhotonics is one the few companies that can design and manufacture precision tuneable lasers with linewidth suitably narrow for coherent network applications. In fact, we became the industry's largest supplier of narrow-linewidth tuneable lasers in 2012," boasts Tim Jenks, Chairman and CEO of NeoPhotonics. "In the micro-ITLA we utilise our PIC technology to minimise the device size and power consumption, while providing our customers with the device performance and production capabilities they need to capture the growth that is apparent in the 100G market space."

3S Photonics & Finisar unite to develop 980nm cooled pump lasers

3S Photonics will be the exclusive supplier of the 980nm laser chips used for a new platform. Finisar will implement a manufacturing line based on this platform in its newly expanded facilities in Wuxi, China

3S Photonics and Finisar Corporation have launched a formal partnership for the development of a new packaging platform for 980nm cooled laser pump modules.

Finisar will use these 980nm pump modules in its EDFA and Line Card products for the telecom market.

3S Photonics will use the packaging platform to serve its own customers.

Alexandre Krivine, CEO of 3SPGroup, comments, “We are very pleased to launch this agreement which will allow 3S Photonics to gain access to an alternative competitive packaging platform that will improve the fixed cost absorption of our wafer fab. We are proud to be selected as the sole supplier by Finisar for these high power applications, which is recognition of the leading performance and reliability of our 980nm chips.”

“This partnership provides Finisar with strategic access to high performance and highly reliable 980nm chips while leveraging our own expertise in high-volume, cost-effective manufacturing,” adds Eitan Gertel, CEO of Finisar. “This combination allows us to quickly provide the products that our customers are demanding to support growing telecom networks.”

The 980nm lasers supplied by 3SPGroup are already fully qualified with outstanding field reliability. The availability of the modules resulting from this new packaging platform is expected by mid-2013.

Solar

UK funds III-V-on-silicon cell development

EPSRC awards £600,000 for new research for solar cells

Huiyun Liu and Alwyn Seeds from University College of London have been awarded £601,519 from the EPSRC to develop low-cost and high-efficiency III-V quantum-dot (QD) solar cells on silicon substrates.

The research will be in collaboration with Bristol University who will do the modelling and characterisation. The grant in total is worth around £1 million over 42 months.

To help combat climate change, the UK has a target to reduce carbon emissions by 80 percent by 2050.

This is a huge task requiring changes to energy generation and supply. To limit the impact on scarce natural resources and the environment, these reductions need to be delivered by providing affordable green energy.

This research project will address this target by developing high-efficiency and low-cost solar cells by growing III-V compound semiconductor self-organised QD structures on cheap and plentiful silicon substrates.

The researchers aim to exploit the advantages of both QD technology and germanium-on-silicon substrates to develop both multi-junction solar cell and intermediate band solar cell design.

UCL will carry out the epitaxial material growth of III-V on germanium-on-silicon substrates by MBE at the department of Electronic and Electrical Engineering, and the device fabrication in the London Centre for Nanotechnology.

Solar Junction & IQE to further develop satellite III-V cells

After surpassing its own world record in October 2012 of nitride based modules of 44 percent efficiency, Solar Junction is teaming up with IQE to supply the European Space Agency

Silicon Valley-based Solar Junction, a developer of

high-efficiency multi-junction solar energy cells for the concentrated photovoltaic (CPV) market, is in contract negotiation with IQE.

IQE is a global supplier of semiconductor wafers for the development of next-generation satellite solar cells for the European Space Agency.

“Solar Junction and IQE have been working closely for the past year as strategic manufacturing partners of the world’s most efficient multi-junction solar cells. Our dilute nitride technology and high-efficiency roadmap is a proven and sustainable pathway for present and future space and terrestrial applications. Winning this contract proves that we’re on-track. We’re proud to be the best solution for the European Space Agency,” states Jim Weldon, CEO of Solar Junction.

Solar Junction surpassed its own world record in October 2012, achieving 44 percent efficiency at a concentration of 942 suns. This record continues to demonstrate the value of its proprietary Adjustable Spectrum Lattice Matched (A-SLAM) architecture.

A-SLAM provides material bandgap tuneability to maximise the absorbed sunlight within CPV modules, thereby increasing the efficiency and energy harvested. Additionally, A-SLAM maintains the lattice-matched paradigm, which has been the foundation of semiconductor and multi-junction solar cell reliability for decades.

Nanowires boost efficiency of solar cells

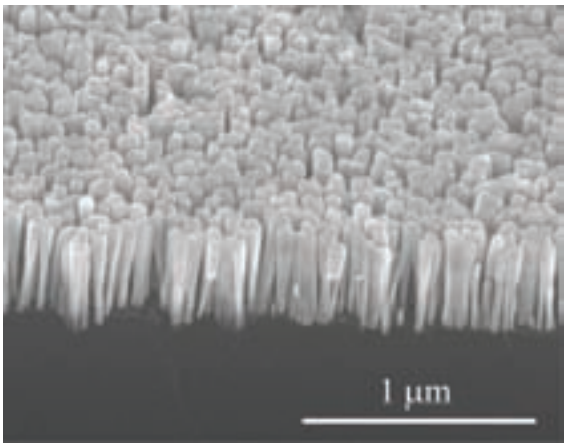
ZnO quantum dots could translates fabrication of large-area films making solar panels

Solar cells made from quantum dots could be low-cost, flexible, and easy to make.

But the efficiency with which they convert light into electricity remains too low for practical use.

Capitalising on the, researchers’ at the Massachusetts Institute of Technology have orating nanowires into quantum dot solar cells.

The cell’s efficiency increases the cells’ efficiency by 35 percent. Quantum dots are semiconductor nanocrystals that absorb different wavelengths of light depending on their size.



Electron micrograph of the nanowire/quantum dot solar cell. (Credit: Joel Jean et al, Bulovic)

Solar cells made from different-sized crystals should absorb light over a much wider range of colours than silicon devices.

What’s more, because quantum dots are made in solution, they could be easily printed or painted onto flexible surfaces. Scientists have calculated that quantum dots could be used to make thin-film solar cells that could convert light to electricity with 15 percent efficiency, the same as commercial silicon devices.

The best-performing quantum dot solar cells consist of a lead sulphide quantum dot layer butted up against a zinc oxide or titanium dioxide layer. The quantum dots absorb light, and electrons created in the process travel to the metal oxide layer to reach the electrical circuit.

The problem is that the quantum dot layer has to be thick enough to absorb light efficiently, but thin enough for the electrons to quickly traverse it.

The MIT researchers, led by electrical engineering and computer science professor Vladimir Bulovic, overcame that trade off by replacing the flat ZnO layer with an array of vertical zinc oxide nanowires.

nanowires penetrate the quantum dot layer, providing conductive paths for the electrons to follow out to the electrical circuit, says Joel Jean, a graduate student in Bulovic’s group. The researchers published their results in the journal Advanced Materials.

The researchers start with glass substrates that are coated with indium tin oxide transparent electrodes. They deposit a ZnO layer on top and float the entire susbtrate upside down in an aqueous solution of zinc precursors.

An array of aligned nanowires grows downwards from the ZnO layer. After about an hour, the researchers rinse the substrates. Finally, they deposit PbS quantum dots,

which fill up the space between the nanowires, and top it off with a gold electrode.

The nanowires boost the output current of the devices by 50 percent and the efficiency by 35 percent over planar ZnO devices. The overall light-to-electricity conversion efficiency of the new devices is 4.9 percent, among the highest reported for ZnO-based quantum dot solar cells, Jean says.

The researchers believe the efficiency could be further enhanced by using thicker light-absorbing layers and longer nanowires, as well as by controlling the spacing between nanowires to better accommodate quantum dots.

The idea of using ZnO nanowires to increase efficiency in quantum dot solar cells is not new, but this is the first significant implementation of the concept, says Matthew Beard, a senior scientist at the National Renewable Energy Laboratory. “The observed efficiency boost is promising and significant,” he says. “The efficiencies for these types of solar cells are increasing rapidly and this work demonstrates that the improvements in efficiency will continue.”

A key advantage of the nanowire-quantum dot cells, says Jean, is that they could be made on large areas. “One of the main benefits of quantum dots is that they’re grown in and deposited from solution,” he says.

“This translates to fabrication of large-area films, which is necessary for making solar panels. Zinc oxide nanowires are also grown in an aqueous solution process. Scalability should be one of the primary practical advantages of this type of solar cell”.

Flow mode DLS shows promise for in-line slurry particle sizing characterisation

Research engineers and scientists at Mega Fluid Systems are investigating Malvern Instruments flow mode DLS technology and developing new methods for CMP slurry.

Koh Murai, VP of Engineering, presented the initial results at the Levitronix 29th European CMP Users Meeting in Zurich, Switzerland. The main objective of the work is to determine feasibility of using flow mode DLS for in-line characterisation of CMP slurry.

The presentation covers methods and apparatus, range of application flow rates, precision, and impact of heating due to extensive recirculation. Key conclusions are flow mode DLS which is promising for in-line slurry particle sizing, and extensive recirculation did not result in measurable changes in mean particle size.

“We are very happy to take an active role in embedding leading-edge technologies, such as Malvern Instruments, into advanced particle measurement techniques critical to the CMP industry,” says Jack McCann, Mega Fluid System’s President. “It is yet another indication that Mega is committed to furthering our leadership position as the world’s superior resource for slurry blend and delivery equipment.”

Mega continues to work on challenges of flow control and accuracy of flow mode DLS.

The new method is expected to provide a platform for in-line, high precision characterisation of particle size distribution over the range 5 to 500nm featuring= chemical and slurry blend and delivery equipment to the global semiconductor, LED, pharmaceutical, specialty chemicals, and solar/PV industries.

Fry`s Electronics and Ascent Solar unite

The CIGS solar cell manufacturer has taken on Fry Electronics to distribute its products

Ascent Solar Technologies, a manufacturer of consumer and off-grid products integrated with flexible thin-film photovoltaic modules has forged a retail relationship with Fry’s Electronics Inc., a California-based retailer.

Surfr for Galaxy S III

Fry's Electronics, founded in 1985 in Silicon Valley, is one of the nation's oldest electronics retailers and is the go-to place for savvy and trend-setting technology consumers. With thirty-four retail locations in nine states, Fry's provides a powerful and unique avenue for Ascent to connect with a highly knowledgeable, affluent and influential end-user customer base.

This relationship establishes Ascent's entry into a premier physical retail presence, further strengthening the company's distribution channels and capabilities.

The EnerPlex Product line has quickly changed the paradigm of solar-integrated consumer electronics, providing consumers with lightweight, powerful and extremely durable charging solutions for all their portable electronics. Surfr, a line of solar- and battery-integrated phone cases, allows users to charge their phone anywhere and in cases of emergency.

Kickr, a line of portable solar chargers, provides a charging solution for most USB-enabled devices, enabling power to be generated almost anywhere and in nearly every situation, perfect for emergency preparedness. With the addition of the Jumpr line of portable batteries, consumers now have a complete, integrated, solar charging and storage solution for life on the go.

Victor Lee, Ascent Solar's President & CEO says, "We at Ascent are extremely excited to begin this promising relationship with Fry's Electronics. We view Fry's as a highly reputable, premier retailer providing the highest value to its discerning consumer base. Fry's is the perfect fit for the EnerPlex line of premium solar-integrated products which enable consumers to get the most out of their electronic devices when away from an outlet."

Ascent Solar's entire EnerPlex series of consumer solar-integrated products is now available at all Fry's retail locations, as well as online through http://www.frys.com/.

Cree SiC MOSFETs solar inverters move forward

Silicon carbide MOSFET technology can significantly improve weight, cost and efficiency in PV inverters

Cree and Delta Energy Systems have made a breakthrough in the photovoltaic (PV) inverter industry with the release of Delta's new generation of solar inverters.

They utilise Cree's SiC power MOSFETs in next-generation PV inverters which can enable significant new milestones in power density, efficiency and weight.

Cree SiC device

"The next-generation PV inverters from Delta are designed to set a new milestone of power density by utilising SiC MOSFETs," comments Klaus Gremmelspacher, head of research and development for PV inverters at Delta Energy Systems. "The SiC MOSFETs from Cree were essential for us to realise our goals for new, high-power inverters that are lightweight and have industry-leading efficiency."

Cree released its first SiC MOSFETs in 2011 and a dramatically improved, second-generation SiC MOSFET in 2013.

Now, as a milestone product announcement, Delta Energy Systems, a subsidiary of Delta Electronics Group, one of the world's largest providers of power management solutions, has incorporated Cree SiC MOSFETs into its next-generation solar power inverter.

Utilising 1200V SiC MOSFET's from Cree in an 11kW PV inverter, Delta has already been able to extend the DC input voltage range while increasing the maximum efficiency of its previous products. The Delta 11kW booster, which employs Cree's SiC MOSFET now has 1kV DC input instead of 900V, is targeted for release in Q2 2013.

Scott Allen, senior director of marketing, Cree Power, remarks, "We are pleased and honoured to have Delta Energy Systems as a customer for our SiC MOSFET. They are utilising the 1200V, 160mΩ MOSFET, which has matured rapidly since its release in 2011 and offers industry-leading performance and cost. Advanced technology customers like Delta are now moving aggressively forward with our SiC MOSFET technology, which enables reduced size, weight and cost for PV inverters, from 20 to 50 percent when compared with silicon, while at the same time maintaining or increasing efficiency."

Packaged SiC MOSFETs from Cree are available from DigiKey and Mouser, and dies are available from SemiDice.

Singulus to outline key steps for CIGS solar panel production

The firm is also looking into large-scale implementable production processes for CIGS solar cell development

Production capacities for CIS/CIGS based cells is anticipated to rise in the coming years.

Based on the CIGS processes, Singulus Technologies (Singulus) can provide customers with its extensive know-how to reduce production costs. The firm also works with its customers to increase cell performance and enhance cell output.

For the development of CIGS solar cells with a substrate size of 300 x 300 mm, Singulus is now offering a modular cluster type tool, the CISARIS. With this machine, innovative and large-scale implementable production processes for CIGS solar cells can be developed targeting new process combinations. Many research and development areas demand such cost-efficient development tools.

CISARIS Rapid Thermal Processing

The company's CISARIS rapid thermal processing oven is designed for the CIGSSe absorber formation on large area glass substrates. The process can safely handle the thermal processing of large glass substrates of over 1 square metre at temperatures up to 600 °C under a toxic and corrosive gas atmosphere.

High heating and cooling rates, combined with an excellent temperature and gas homogeneity during all process stages are the key factors which allow the formation of an optimal CIGSSe absorber required for the production of high efficiency solar modules.

CISARIS consists of a handling station, a vacuum tight process section, and a return conveyor and is optimised for the mass production of CIS solar modules., CISARIS provides a production capacity of over 25 MWp per year

Sputtering Systems

Singulus is also offering new processing systems for vacuum coating CIGS thin-film solar cells. The systems respond to the demand in the photovoltaic industry for development and production tools that enhance the efficiency of thin-film solar cells, while cutting production costs.

For PV technology, Singulus develops and manufactures coating systems which can apply special layers and layer systems on different materials. Inline sputter systems are significant in today's thin-film solar cell production.

New Generation of Wet Process Equipment for Economic Processing of CdS/Alternative Buffer Layer for CIGS Solar Cells

Singulus has also made a promising new development to the efficient wet-chemical coating of thin-film solar modules made of copper-indium-gallium-diselenide (CIGS) on glass: the second generation of the TENUIS production which has a modular cluster build enables both significant savings in terms of required floor space and the simultaneous one-side coating of two substrates.

Singulus offers wet processing systems from R&D over pilot use to full production range 60, 120, 180 and more MW.

Due to new and unique concepts in terms of dosing and temperature control, Singulus` developers were successful in reducing the process time by up to 20 percent, which has a positive effect and a considerably higher output in production.

Inline Wet Process Equipment, Etching, Cleaning & Single Side Coating for Thin-Film Solar Cells

The modular design of the Singulus inline wet process equipment VITRUM II allows the easy integration of different process steps according to the requirements of CIGS, a-Si or CdTe technology (etching, rear side and substrate edge etching, cleaning, and single side coating).

The design of the VITRUM II features similar piping for all liquid circuits and generously dimensioned installation compartments for optimised maintenance work.

The second generation VITRUM enables homogeneous, reliable and reproducible etching. It features further advantages in comparison to a dipping bath, such as a higher etch length and concentration, a higher process speed of up to 5 m/min, and minimized carryover.

The design of the VITRUM GEN 2 improves the accessibility for optimized maintenance work in a large installation cabinet. Piping is similar for all liquid circuits. It offers a high cycle rate and is also easy to integrate into existing production lines.

Optimising the harvesting of sunlight

A gallium nitride based single-photon emitter can secure communication

University of Michigan researchers have developed a new device that could make the advanced form of secure communications known as quantum cryptography more practical.

The U-M scientists have demonstrated a simpler, more efficient single-photon emitter that can be made using traditional semiconductor processing techniques.

Single-photon emitters release one particle of light, or photon, at a time, as opposed to devices like lasers that release a stream of them.

Single-photon emitters are essential for quantum cryptography, which keeps secrets safe by taking advantage of the so-called observer effect: The very act of an eavesdropper listening in jumbles the message. This is because in the quantum realm, observing a system always changes it.

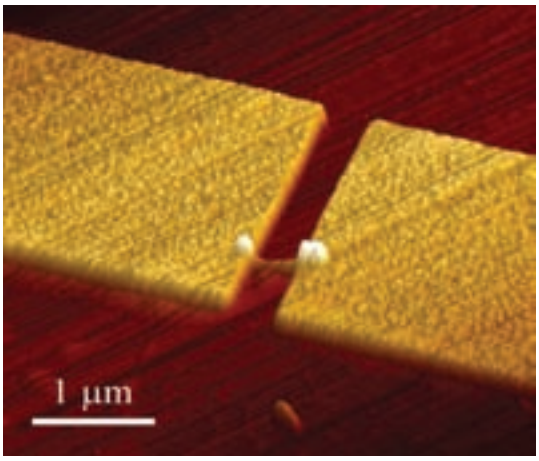
For quantum cryptography to work, it's necessary to encode the message - which could be a bank password or a piece of military intelligence, for example - just one photon at a time. That way, the sender and the recipient will know whether anyone has tampered with the message.

While the U-M researchers didn't make the first single-photon emitter, they say their new device improves upon the current technology and is much easier to make.

"This thing is very, very simple. It is all based on silicon," says Pallab Bhattacharya, the Charles M. Vest Distinguished University Professor of Electrical Engineering and Computer Science, and the James R. Mellor Professor of Engineering.

Bhattacharya, who leads this project, is a co-author of a paper on the work published in *Nature Communications* on April 9th.

Bhattacharya's emitter is a single nanowire made of gallium nitride (GaN) with a very small region of indium gallium nitride (InGaN) that behaves as a quantum dot. A quantum dot is a nanostructure that can generate a bit of information. In the binary code of conventional computers, a bit is a 0 or a 1. A quantum bit can be either or both at the same time.



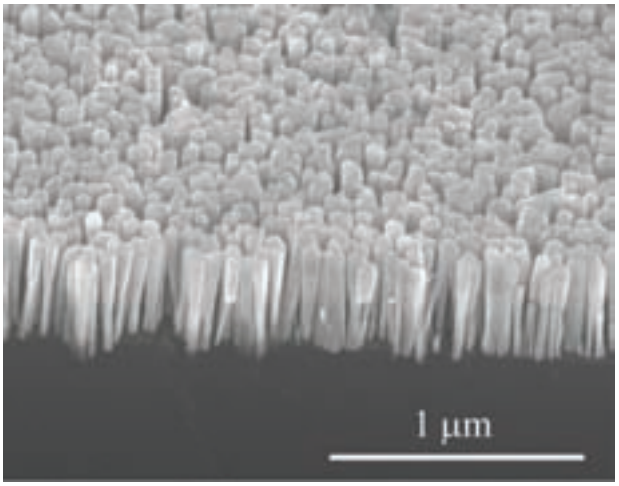
An atomic force microscope image of a nanowire single photon emitter. (Courtesy of Pallab Bhattacharya)

The semiconducting materials the new emitter is made of are commonly used in LEDs and solar cells.

The researchers grew the nanowires on a silicon wafer. Because their technique is silicon-based, the infrastructure to manufacture the emitters on a larger scale already exists. Silicon is the basis of modern electronics.

"This is a big step in that it produces the pathway to realising a practical electrically injected single-photon emitter," Bhattacharya says.

Key enablers of the new technology are size and compactness.



SEM image of nanowires growing on silicon. (Courtesy of Pallab Bhattacharya)

"By making the diameter of the nanowire very small and by altering the composition over a very small section of it, a quantum dot is realised," Bhattacharya explains. "The quantum dot emits single-photons upon electrical excitation."

The U-M emitter is fuelled by electricity, rather than light - another aspect that makes it more practical. And each photon it emits possesses the same degree of linear polarisation. Polarisation refers to the orientation of the electric field of a beam of light. Most other single-photon emitters release light particles with a random polarisation.

“So half might have one polarisation and the other half might have the other,” Bhattacharya says. “So in cryptic message, if you want to code them, you would only be able to use 50 percent of the photons. With our device, you could use almost all of them.”

This device operates at cold temperatures, but the researchers are working on one that operates closer to room temperature.

Further details of this work are in the paper, “Electrically-driven polarized single-photon emission from an InGaN quantum dot in a GaN nanowire,” by S. Deshpande *et al* in *Nature Communications*, 2013, 4. 1675. DOI: 10.1038/ncomms2691

The work is supported by the National Science Foundation. The device was fabricated at the U-M Lurie Nanofabrication Facility.

First Solar purchases Californian 60 MWAC project

The (CdTe) cadmium telluride manufacturer’s new project will create up to 430 construction jobs and is expected to finish in 2015

First Solar has acquired the 60 megawatt AC (MW) North Star solar project that NorthLight has developed in Fresno County, California.

NorthLight is a joint venture between Renewable Energy Corporation ASA and Summit Power Group, LLC.

Terms of the transaction were not disclosed.

The photovoltaic (PV) solar plant is expected to start construction in 2014 and be completed in 2015, providing up to 410 construction jobs.

When fully operational, it will produce enough clean, renewable energy to power over 21,000 average California homes while displacing approximately 33,000 metric tons of water consumption and 39,000 metric tons of CO2 per year - the equivalent of taking about 7,500 cars off the road each year.

The North Star project is located near the city of Mendota and has a 20-year power purchase agreement with Pacific Gas and Electric Company.

“We’re excited to be acquiring and constructing our first utility-scale photovoltaic power project in Fresno County,” says James F. Cook, First Solar Director of Project Development. “North Star will provide much-needed construction employment in a hard-hit economy, while helping the state satisfy its renewable energy requirements.”

“Summit Power Group is pleased to be working with First Solar on this project,” comments Dana Zentz, Vice President of Commercial Development for Summit and Managing Director of NorthLight Power. “We have received and been thankful for tremendous support from the local community, and look forward to continuing success with other solar projects that are in our current development portfolio within NorthLight Power.”

European GaN devices to go into orbit

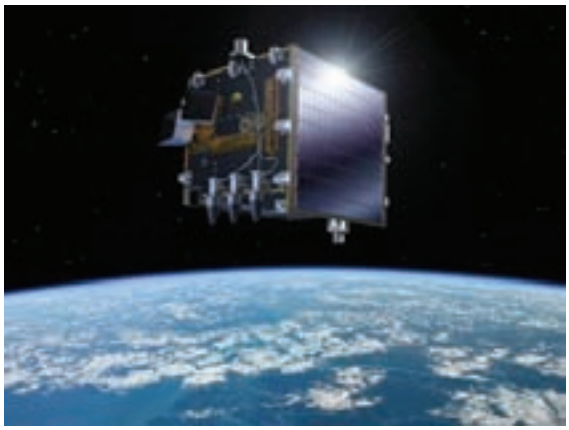
For the first time, a European gallium nitride based device will fly into space. It will monitor environmental occurrences in places such as the rain forest and the sea

When satellite Proba-V flies into space in the coming weeks to begin its earth observation, a device based on the semiconductor GaN will be on board.

Being more robust, more compact and lighter than traditional solutions, the new technology promises to significantly improve communication electronics in space.

In the course of an intensive test series, the amplifier developed by the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg has qualified itself for the journey into space.

The satellite which the European Space Agency ESA will launch into space for earth observation weighs about 140 kg and is only roughly the size of a washing machine. The mini-satellite Proba-V is covered in solar cells and will be observing the vegetation on earth. Every other day, the environmental satellite will send pictures from a distance of about 820 km. Rain forest destruction, pollution of the seas and soil erosion will be made visible by pictures taken in various spectral ranges.



The mini-satellite Proba-V (© ESA – P. Carril)

"GaN has the potential to revolutionise communication in space. We expect signal strength and data transmission to improve five or tenfold," says Andrew Barnes, who is responsible for the project at ESA. "We are eagerly awaiting the results of the first practical test in space".

The institute in Freiburg has developed an amplifier circuit for the frequency range of 8 - 8.5 GHz (X-band) for the communication system of Proba-V. Tesat-Spacecom in Backnang, in cooperation with SCHOTT Electronic Packaging, then packaged the GaN amplifier together with further components into a hermetically sealed housing suitable for space travel.

GaN in stress tests: robust and reliable

GaN devices can be operated under much higher voltages and temperatures than traditional silicon or GaAs components. The circuits are more compact, smaller and lighter than other solutions.

They might even replace electron tubes currently used for amplification. This would significantly reduce weight and transport costs, which can amount to €30,000 per kilogram of payload. Due to the long lifetime and radiation hardness of the semiconductor material, such electronic devices are ideally suited for the extreme conditions posed by aerospace.

Before being admitted for space travel, however, the GaN device had to prove its resilience. The device was exposed to cold and heat, strong vibration and motion as well as radiation.

"Accelerated lifetime tests, conducted together with Tesat-Spacecom, have shown that our GaN amplifier will live for at least 20 years", says Patrick Waltereit, project leader at Fraunhofer IAF. "The approval of our device for the flight into space is an important milestone for the further development of GaN technology, also for other areas of application".

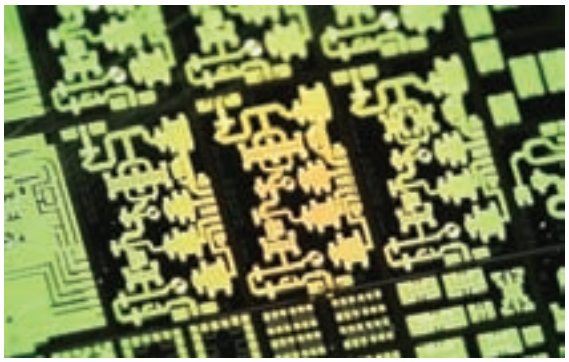
Power semiconductor pushes the limits of silicon technology

Due to its exceptional physical properties, GaN is ideally suited for applications in power electronics.

Compared to conventional semiconductors such as silicon and GaAs, GaN possesses a larger bandgap (3.4 eV) and higher breakdown field strength (3.3 MV/cm). Higher dielectric strength and current density result in a fivefold increase in power density.

What's more, the usable frequency range is larger in GaN, which allows several functions to be integrated on one chip.

The thermal robustness of the semiconductor results in a considerable decrease of cooling effort, which is both energy- and cost-efficient. This makes compact and energy-efficient GaN devices interesting not only for applications in aeronautics, but also for voltage converters for the batteries of electric cars, solar panels or household appliances. As such, these devices offer high potential especially for applications which demand high performance and long lifetime even in harsh environmental conditions. This is where silicon technology meets its limits.



GaN based processed X-band amplifier circuits. The circuit for Proba-V has a size of 2 x 3.5 mm2 (© Fraunhofer IAF)

The project

The European Space Agency ESA founded the initiative Great ("GaN Reliability Enhancement and Technology Transfer Initiative") in order to exploit the potential of GaN technology for aeronautics.

Together with industrial partners, renowned research institutes in the field of III-V semiconductors, such as Fraunhofer IAF, develop high quality GaN-based devices under the project leadership of Tesat-Spacecom, thus strengthening the competitiveness of the European aerospace industry.

First Solar takes on VP for business development in Middle East

GE veteran Ahmed Nada is expected to help to spread the firm's CdTe (cadmium telluride) technology in this region

First Solar has appointed Ahmed Nada as Vice President of Business Development for the Middle East.

He will report to Christopher Burghardt, VP of Business Development for Europe, Middle East and Africa (EMEA).

In this new role, Ahmed will be based in the company's Dubai office and will lead business development activities in the region outside of Saudi Arabia, where the company is also establishing operations.

Nada has 20 years of experience throughout the Middle East, concentrated in the energy and power industries. He joins First Solar after 14 years with General Electric. He most recently was the business executive and regional general manager of GE Oil & Gas Global Services in the Middle East. Prior to that Ahmed worked at Zahid Tractors & Heavy Machinery Co, a Caterpillar distributor in Saudi Arabia, and Saudi Arabian Marketing Corp. (SAMACO).

"The Middle East is just beginning to tap its immense potential solar power generation, and Ahmed's many years of experience working with the region's leading energy companies will help us to meet the growing demand for renewable energy in the region," comments Christopher Burghardt.

"Utility-scale solar power offers a compelling solution to the region's growing energy needs, and this is a great opportunity to leverage First Solar's proven technology and global experience to provide the best value to our customers here," says Ahmed Nada.

Nada holds a Master's of Science degree in international management from HEC Lausanne University in Switzerland.

CVD Equipment sells off former corporate HQ

The aim of the sale was to generate funds to increase sales and operations in the company's new 130,000 square foot manufacturing facility

On April 5th, 2013 CVD Equipment Corporation completed the sale of its 50,000 square foot facility located at 1860 Smithtown Avenue, Ronkonkoma, New York where its former corporate headquarters had been located.

The sale price of the premises was $3,875,000, representing an estimated profit of approximately $900,000 to CVD.

Leonard Rosenbaum, President and Chief Executive Officer comments, "The sale closes a chapter of our company's history and highlights a new chapter as our attention and efforts are focused towards increased sales and operations in our new 130,000 square foot facility where we will be expanding our i) Equipment manufacturing and Nano material manufacturing capabilities, ii) Pilot production process development and demonstration for the transformation of nano materials to macro sized materials and iii) Joint business/technology developments for products enabled by nano materials to be marketed through our wholly owned subsidiary, CVD Materials Corporation."

CVD Equipment Corporation) is a designer and manufacturer of customised and standard equipment used in the development, design and manufacture of advanced electronic components, materials and coatings for research and industrial applications. The firm's CVD, deposition, gas control, and other equipment is used in the growth of many materials and devices including LEDs, solar cells and III-V nanowires.

First Solar to acquire silicon cell manufacturer TetraSun

Tetrasun's high-efficiency, low-cost mono-crystalline silicon solar cells cell technology complements First Solar's CdTe thin-film expertise. It offers an optimal solution for distributed generation and high energy density applications

First Solar is acquiring TetraSun, a solar photovoltaic (PV) technology startup.

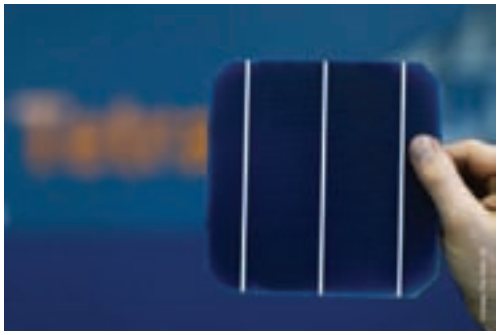
Tetrasun has developed a break-through cell architecture capable of conversion efficiencies exceeding 21 percent with commercial-scale manufacturing costs comparable to conventional multicrystalline silicon solar cells.

First Solar signed a definitive agreement to acquire TetraSun from JX Nippon Oil & Energy Corporation and other investors, including TetraSun management.

Terms of the transaction, which is expected to close in

the second quarter of 2013, were not disclosed.

First Solar and JX Nippon Oil & Energy have also entered into discussions on an agreement to distribute the technology in Japan.



Tetrasun monocrystalline silicon solar module

TetraSun's core technology is a proprietary cell architecture which breaks the historical tie between high-efficiency and high-cost.

Compared to other high-efficiency crystalline silicon cells, TetraSun's advanced cell design is simpler and optimised for manufacturing, requiring fewer process steps with wider tolerances. The design enables high-volume production with higher yields using readily available equipment.

Cost-effectiveness is further enhanced by using large-format (156 mm) *n*-type wafers and eliminating the need for expensive silver and transparent conductive oxide. The technology also benefits from a low temperature coefficient of power, which produces superior energy yields in hot climates compared to typical silicon PV modules.

First Solar tentatively plans to begin commercial-scale manufacturing of the new technology in the second half of 2014.

"This breakthrough technology will unlock the half of the PV market which favours high-efficiency solutions, which has been unserved by First Solar to date," says Jim Hughes, CEO of First Solar. "This new capability to meet the needs of customers with distributed generation applications, coupled with our leading CadTel offering which remains the benchmark for utility-scale systems, gives us a unique end-to-end suite of solutions to serve the full spectrum of commercial applications."

"We are proud to join the First Solar team, which brings global reach, financial strength and a proven track record scaling disruptive technologies," comments Denis De Ceuster, CEO of TetraSun. "This is a game-changing technology, and with First Solar we have the freedom to continue our blank-canvas approach, unconstrained by pre-existing designs or production equipment, and backed by the strongest balance sheet in the industry."

"JX Nippon Oil & Energy was among the first to recognise the potential of this technology, and we are very pleased to continue working with this leading energy company to bring this product to market," says Jim Hughes. "Japan is an important market with unique energy challenges, and we believe this new technology is well-suited to help them meet their energy needs."

All fourteen of TetraSun's associates will join First Solar and continue to be based in San Jose, California. The technical team brings First Solar significant expertise in silicon PV R&D and a track record of innovation at companies like SunPower and Fraunhofer ISE, where they earned world-records for silicon cell efficiency.

Opel appoints new directors to pioneer GaAs POET technology

The two appointments have vast experience in both III-V and silicon technology

Opel Technologies Inc. has appointed Adam Chowaniec and Geoff Taylor to its Board of Directors ; this brings an increase in the number of directors from 6 to 8.

Adam Chowaniec was previously the founding Chief Executive Officer (CEO) and Chairman of Tundra Semiconductor (acquired by Integrated Device Technology), Chairman of Zarlink (acquired by Microsemi), and Chairman of Bel Air Networks (acquired by Ericsson).

Prior to that he was President and CEO of Calmos Systems, acquired by Newbridge Networks and renamed Newbridge Microsystems, where he served as President and as a Vice President of Newbridge Networks.
He has also served on the boards of SiberCore Technologies, Liquid Computing, Microbridge, GEAC and Amiga. He currently serves on the boards of Solantro Semiconductor.

Chowaniec holds an M.Sc. in Electrical Engineering from Queen's University and a B.Sc. and Ph.D. from the University of Sheffield. In 2010, he was recognised by the California Computer Museum as one of the founding fathers of the personal computer.

"We are extremely pleased to have Chowaniec onside," notes Peter Copetti, Executive Director of Opel. "His reputation and industry standing enhance the Board's strategy to magnify the value of Opel's semiconductor

technology." Copetti adds, "The Board is also pleased to align itself with the vision of Dr. Taylor, recognising his role as the primary architect of our technology platform."

Geoff Taylor is Chief Scientist at Opel and has led development of the Planar Optoelectronic Technology (POET) platform over the past two decades, directing a team at the Odis subsidiary of Opel.

Taylor possesses an extraordinary technical background made-up of 30 years of design and development experience in electronic and optical device physics, circuit design, opto-electronic technology, materials and applications.

He is also a Professor of Electrical Engineering and Photonics at the University of Connecticut and is responsible for Odis' development efforts at the GaAs growth and fabrication facility.

With over 150 papers and dozens of patents, Taylor is widely regarded as an authority on GaAs solid-state physics, III-V opto-technology, as well as one of the pioneers in the development of monolithic integrated opto-electronic circuits.

Previously, Taylor served as a Distinguished Member of the technical staff at AT&T Bell Labs, developing inversion channel technology for III-V materials. At Honeywell and Texas Instruments he helped to develop critical optical technology for the Jupiter Orbital Probe as well as the development of key circuits and devices for very-large-scale integrated (VLSI) chips.

He also holds a Ph.D. in Electrical Engineering and an M.A.Sc. in Electrical Engineering
from the University of Toronto and a B.Sc. in Electrical Engineering from Queen's University.

A core component of Opel's forward strategy is to continue optimisation of the POET platform, which enables monolithic fabrication of integrated circuit GaAs devices containing both electronic and optical elements on a single wafer.

By enabling increased speed, density, reliability, power efficiency, and much lower bill-of-materials and assembly costs, POET provides a new technology direction and opportunity for the semiconductor industry.

POET will allow continued advances of semiconductor device performance and capabilities for many years, overcoming the current power and speed bottlenecks of silicon-based circuits, and will change the future development roadmaps of a broad range of semiconductor applications including mobile devices, computer servers, storage arrays, imaging equipment, networking equipment, transportation systems, and test and measurement instruments.

Chowaniec and Taylor were each granted stock options to purchase 500,000 shares, at an exercise price of $0.51 per share, expiring on April 2nd, 2018. The price was determined as the closing trading price on the TSX Venture Exchange on the previous trading day being April 1st, 2013. The options vest 25 percent immediately and 25 percent every six months thereafter, and are dependent on the approval of the amended Stock Option Plan by the TSX Venture Exchange.

CdTe manufacturer First Solar strikes gold in California project

The cadmium telluride cell manufacter's acquisition will generate enough electricity to power more than 60,000 average homes

First Solar has acquired the 150-megawattAC (MW) Solar Gen 2 power project from an affiliate of The Goldman Sachs Group, Inc., Energy Power Partners and a third equity partner for the project.

Construction of the facility, which is located in Imperial County, California, near El Centro, is expected to start this year and be completed in 2014.

The photovoltaic (PV) solar plant will generate enough electricity to power more than 60,000 average California homes, displacing more than 115,000 metric tons of CO2 per year (the equivalent of taking 22,000 cars off the road) and saving 93,000 metric tons of water per year.

The electrical output of the project will be purchased by San Diego Gas & Electric Company (SDG&E) under a 25-year power purchase agreement. Solar Gen 2 is expected to provide on average more than 800 construction jobs in Imperial County, an area currently suffering from high unemployment.

"We are very pleased to help SDG&E meet its clean energy goals and provide clean, reliable, renewable power to their customers," says Dana Diller, First Solar Vice President of U.S. Business Development.

"We are also proud to once again bring the economic benefits of utility-scale solar development to Imperial County, where both county officials and the Imperial Irrigation District, with which this plant will interconnect, have been extremely supportive."

"We are delighted to transition Solar Gen 2 to First Solar, one of the world's leading solar companies. First

Solar shares our vision of providing clean energy for California and green jobs for Imperial Valley, one of the most economically challenged areas in the country," adds Steve Zaminski, CEO of Solar Gen 2 and owner of Energy Power Partners.

"We are grateful to SDG&E, the Imperial Irrigation District, the County of Imperial and the California Public Utilities Commission for their leadership and support in contributing to the successful outcome of this development effort."

Financial terms were not disclosed. The acquisition includes 40 MWDC of solar modules that the project previously purchased from another supplier, which will be integrated into the installation. First Solar will supply the balance of modules for the power plant, along with its project development, engineering, procurement and construction and grid integration services.

PacWest acquires DayStar's CIGS technology

Analysts say the deal to buy the copper indium gallium diselenide technology was valued at more than $55 million

PacWest Equities has acquired DayStar Technologies' line of CIGS Solar Technology.

The deal includes the ownership of DayStar's 15 Chamber CIGS production line. It produces solar covered glass panels at the rate of one 2 x 4 sheet per minute, which is of significant importance to PacWest Equities' wholly owned subsidiary, World EcoSource's MobileFood and MobileFeed Organic Food and Feed production lines.

This technology purchase also includes the DayStar library of 51 patents, patents pending, and international patents.

The technology cost over $100 million to develop, with $67 million going to Research and Development, $12 million to build the prototype line, and $27 million going to the actual production line now in physical possession of PacWest Equities, Inc.

This technology is designed to integrate with other technologies in the building market, but at the same time opening up huge surface areas for Solar Generation that previously were tinted, coated, and usually curtained to attempt to stop the transfer of heat and energy drain.

PacWest Equities, Inc. specialises in working with under performing companies and bringing together the resources needed for them to attain financial stability and growth. The firm's focus is on recession proof industries such as food and energy production showing a positive upside while struggling to bring new bio-technologies and unique products to market.

Miasolé to provide India with 11.6MW of CIGS solar power

The U.S. Export-Import Bank has provided project financing to support MiaSolé California exports

Indian power developer KSK Energy Ventures and CIGS manufacturer MiaSolé have commissioned an 11.6MW solar photovoltaic project which occurred on February 26th, 2013.

The project is under India's Jawaharlal Nehru National Solar Mission and is one of the largest solar power plants in Rajasthan, India.

U.S. Export-Import Bank will provide $9 million of debt financing for the project, marking the second MiaSolé project in India that the bank has supported.

"This project financing facilitates exports from MiaSolé's California manufacturing centre, will boost California's economy and help to create hundreds of local jobs," says U.S. Export-Import Bank Chairman Hochberg.

Over the past year, MiaSolé has completed projects in Rajasthan, Gujarat, Maharashtra and Tamil Nadu, making MiaSolé one of India's leading providers of solar energy.

"We are pleased to partner with MiaSolé to deliver clean energy to our customers and drive continued growth for us in this market," says Anil Kumar Kutty, Director of KSK. "MiaSolé CIGS solar panels have proven to deliver the best solution for our project and are a compelling solution for the India market."

"India represents a tremendous opportunity for renewable energy, and we are pleased to partner with a leading company like KSK in its efforts to deliver clean energy resources in Rajasthan," comments John Carrington, CEO of MiaSolé.

In 2013, MiaSolé also plans to expand its global footprint and business model to invest in projects, acquire project pipelines and partner with leading developers and EPC companies in sustainable markets like India.

What's more, Ex-ImBank's support of MiaSolé's

technology lowers the cost of project financing, and will expand the employment of MiaSolé's California - made solar modules in projects globally.

MiaSolé's headquarters and manufacturing are located in California, where the company employs approximately 200 people.

In 2013, the company plans to hire over 200 additional employees in California to expand its manufacturing, research and development and commercial activities.

III-V or silicon for solar?

Costs or efficiency - can there be a middle ground

Yole Développement's "High-Concentration Photovoltaics Business and Technology Update" report, says the key factors to improve the bankability of HCPV installation projects and a new analysis to guide strategic business decisions are related to this technology.

This is not new - III-V solar cell efficiency is far better than silicon and other technologies although it may be more expensive.

Yole has updated its 2012 edition market data for wafers, epiwafers and installation,costs of HCPV (High-Concentration Photovoltaics) modules and systems.

The company says that since March 2013, approximately 120 HCPV installations have been installed throughout the world, accounting for a total capacity of about 130 MW. This iestimate is approximately a thousandth of the total installations of flat-plate PV, represented mainly by crystalline silicon.

The main advantage of HCPV over flat-plate PV is high efficiency - surpassing 40 percent (at cell level), and reaching about 30 percent at module level.

This efficiency level is not achievable by conventional PV technologies. Yole details in its report that the high efficiency of HCPV systems will be the key driver for HCPV in the future.

The HCPV cell efficiency must be significantly increased (without increasing manufacturing costs too much) in order to increase the differentiation between HCPV and its strong competitor, conventional flatplate PV, and to reduce the system costs.

The high system efficiency, together with high electricity production (kWh/kW installed), makes HCPV Levelised Cost of Electricity (LCOE) competitive with that of fossil-fuelled power plants in some sunny locations.

Most technology challenges identified early, at the beginning of HCPV development, have been resolved already. However, today's relatively weak HCPV market development is related not only to the technology issues, but also to the lack of financing and low interest among potential customers.

To speed up the HCPV market growth, the bankability of HCPV projects must be improved at all levels, including technology development and testing, and minimising the uncertainty about the solar resources at the future installation site, etc.

This Yole report deals with the factors that can improve the bankability of HCPV installation projects and help the HCPV market to grow. Based on future technological achievements and improved bankability, two scenarios - conservative and optimistic - are proposed for the 2013-2020 HCPV market evolution.

As the HCPV market is very restricted, there is not much place for less-competitive players. Several companies have recently stopped or reduced their HCPV activity due to either strong competition or losing interest in a small and low-margin market such as HCPV is today.

The leaders are not yet established, and new companies with innovative technology or business models may take a lead in the future.

As shown in Yole's report, with a boisterous demand, there will be an increasing trend for vertical integration in the near future. Although more vertical integration is associated with a higher business risk, it enables better control of the system performance and total system costs.

The (at least) partial vertical integration together with 100 MW+ in-house production capacities may enable companies like Suncore or Soitec to get a significant advantage compared to their competitors.

"An alternative approach is to subcontract most of the business and thus lower a company's capital needs and at the same time transfer most of the business risk to subcontractors. This approach is advantageous for small companies with limited sources of financing. In the report we analyze both approaches," says Milan Rosina, Market & Technology Analyst, Photovoltaics, at Yole Développement.

The performance of each individual element of an HCPV system says nothing about the performance of the whole system. All elements must be carefully optimised and matched in order to get optimal system performance, as shown in this report.

The analysis of different approaches (germanium

vs. GaAs wafer, PMMA vs. SOG optics, etc.) allows identification of the main technology trends as well as materials and manufacturing techniques used. It helps to evaluate the potential of different HCPV components for cost reduction and performance enhancement.

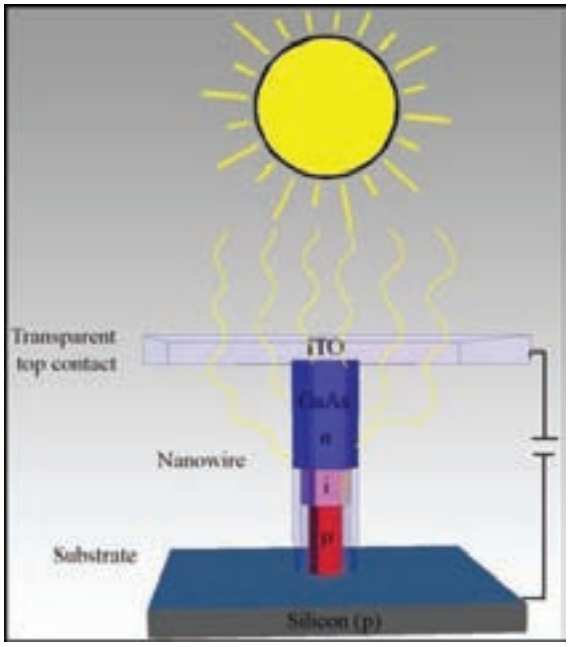
GaAs nanowire solar cells have massive potential

Cylindrical III-V nanowire structures are predicted to have great potential in the development of solar cells, quantum computers and other electronic products

Scientists have shown that a single nanowire can concentrate the sunlight by up to 15 times of normal sunlight intensity.

The researchers who made the discovery come from the Nano-Science Centre at the Niels Bohr Institut, Denmark and the Ecole Polytechnique Fédérale de Lausanne, Switzerland.

Surprised with the results, the team believe their latest data shows the potential for developing a new type of highly efficient solar cell.



Above, the sun's rays are drawn into a nanowire, which stands on a silicon substrate. At a given wavelength the sunlight is concentrated by up to 15 times (Credit: Niels Bohr Institute)

Due to some unique physical light absorption properties of nanowires, the limit of how much energy can be utilised from the sun's rays is higher than previously believed, say the researchers.

These results demonstrate the great potential of development of nanowire-based solar cells says Peter Krogstrup, a Ph.D. scientist who worked on the project and is one of the authors of a recent paper published in *Nature Photonics.*

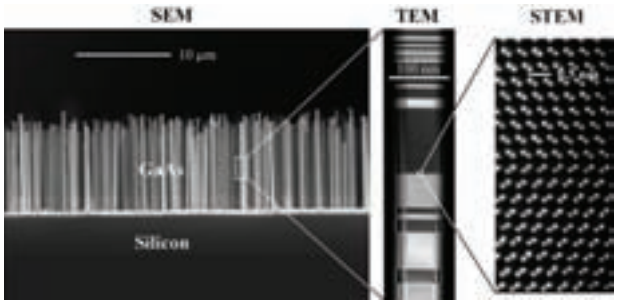
In the past few years, the project researchers have developed and improved the quality of the nanowire crystals. These crystals have a cylindrical structure with a diameter of about 10,000 part of a human hair.

The team members believe their nanowire technology could have great potential in the development of not only solar cells, but also next generation quantum computers and other electronic products.

It turns out that the nanowires naturally concentrate the sun's rays into a very small area in the crystal by up to a factor 15.

And because the diameter of a nanowire crystal is smaller than the wavelength of the light coming from the sun, it can cause resonances in the intensity of light in and around nanowires.

Peter Krogstrup points out the resonances concentrate the sunlight, leading to a higher conversion efficiency of the sun's energy.



Various microscope images of the GaAs nanowire structure

New efficiency limit

The typical efficiency limit - the so-called "Shockley-Queisser Limit," has for many years been a landmark for solar cell efficiency among researchers, but now it seems that it may be increased.

The scientists point out that their exciting discovery could move the theoretical limits. And moving the limit by only a few percent should have a major impact on the development of solar cells, exploitation of nanowire solar rays and perhaps the extraction of energy at international level.

However, it will take some years before production of solar cells consisting of nanowires becomes a reality, acknowledges Krogstrup.

This research was conducted in collaboration with the Laboratory des Matériaux Semiconducteurs, Ecole Polytechnique Fédérale de Lausanne, the Foundation and the company SunFlake A / S.

The scientific findings reported here support results published in the journal *Science* in January. Here, a group of researchers from Lund, showed that the sun's rays was sucked into the nanowires due to the high amount of power that their solar cell produced.

Link solar-cells with dots and wires

MIT researchers have improved the efficiency of a quantum-dot photovoltaic system by adding a forest of nanowires

Using quantum dots as the basis for a photovoltaic cell is not a new idea, but attempts to make such devices have not yet achieved sufficiently high efficiency in converting sunlight to power.

Now a new wrinkle added by a team of researchers at MIT - embedding the quantum dots within a forest of nanowires - promises to provide a significant boost.

Photovoltaics (PVs) based on tiny colloidal quantum dots have several potential advantages over other approaches to making solar cells.

For one, they can be manufactured in a room-temperature process, saving energy and avoiding complications associated with high-temperature processing of silicon and other PV materials.

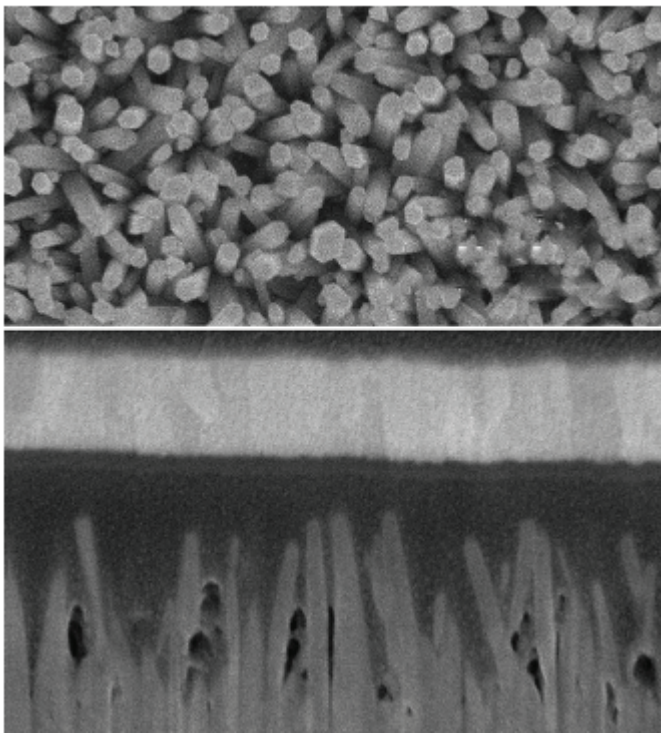
They can be made from abundant, inexpensive materials that do not require extensive purification, as silicon does. And they can be applied to a variety of inexpensive and even flexible substrate materials, such as lightweight plastics.

But there's a trade-off in designing such devices, because of two contradictory needs for an effective PV.

Firstly, a solar cell's absorbing layer needs to be thin to allow charges to pass readily from the sites where solar energy is absorbed to the wires that carry current away - but it also needs to be thick enough to absorb light efficiently. Improved performance in one of these areas tends to worsen the other, says Joel Jean, a doctoral student in MIT's Department of Electrical Engineering and Computer Science (EECS).

"You want a thick film to absorb the light, and you want it thin to get the charges out," he adds. "So there's a huge discrepancy."

That's where the addition of zinc oxide nanowires can play a useful role, says Jean, who is the lead author of a paper to be published in the journal *Advanced Materials*.



Scanning Electron Microscope images show an array of zinc-oxide nanowires (top) and a cross-section of a photovoltaic cell made from the nanowires, interspersed with quantum dots made of lead sulphide (dark areas). A layer of gold at the top (light band) and a layer of indium-tin-oxide at the bottom (lighter area) form the two electrodes of the solar cell. (Images courtesy of Jean, et al/Advanced Materials)

These nanowires are conductive enough to extract charges easily, but long enough to provide the depth needed for light absorption, Jean says.

Using a bottom-up growth process to grow these nanowires and infiltrating them with lead-sulphide quantum dots produces a 50 percent boost in the current generated by the solar cell, and a 35 percent increase in overall efficiency, Jean says. The process produces a vertical array of these nanowires, which are transparent to visible light, interspersed with quantum dots.

"If you shine light along the length of the nanowires, you get the advantage of depth," he says. But also, "you

decouple light absorption and charge carrier extraction, since the electrons can hop sideways onto a nearby nanowire and be collected."

One advantage of quantum dot-based PVs is that they can be tuned to absorb light over a much wider range of wavelengths than conventional devices, Jean says. This is an early demonstration of a principle that, through further optimization and improved physical understanding, might lead to practical, inexpensive new kinds of photovoltaic devices, he says.

Already, the test devices have produced efficiencies of almost 5 percent, among the highest ever reported for a quantum-dot PV based on zinc oxide, he says. With further development, Jean says, it may be possible to improve the devices' overall efficiency beyond 10 percent, which is widely accepted as the minimum efficiency for a commercially viable solar cell.

Further research will explore using longer nanowires to make thicker films, and also work on better controlling the spacing of the nanowires to improve the infiltration of quantum dots between them.

This research has been described in depth in the paper, "ZnO Nanowire Arrays for Enhanced Photocurrent in PbS Quantum Dot Solar Cells" by Joel Jean *et al* in *Advanced Materials.* DOI: 10.1002/adma.201204192

The team was supported by the National Science Foundation; the MIT Centre for Materials Science and Engineering; the Samsung Group; the MIT/Masdar Institute Cooperative Program; the MIT Energy Initiative; the Hertz Foundation; and the Agency for Science, Technology and Research of Singapore.

Magnolia Solar CIGS achieve 13 percent efficiency

The copper indium gallium diselenide modules are targeted at the defence and commercial industry

Magnolia Solar's wholly owned subsidiary, Magnolia Solar, Inc., has demonstrated a flexible CIGS solar cell with an efficiency of 13 percent.

This rivals the average efficiency of current PV technologies and proves that flexible thin film solar cells could be a viable solution for many energy needs.

The flexible CIGS solar cell, made using thin, flexible stainless steel and titanium substrates, were developed and produced by the U.S. Photovoltaic Manufacturing Consortium (PVMC).

This was on behalf of Magnolia Solar at the College of Nanoscale Science and Engineering's (CNSE) Solar Energy Development Centre (SEDC) located in Halfmoon, New York.

This flexible solar cell demonstration is the result of a successful and continuing collaborative research effort between Magnolia Solar, CNSE, and PVMC, and is supported by the New York State Energy Research and Development Authority (NYSERDA).

To increase the adoption of game-changing clean energy solutions, Magnolia Solar intends to continue to work with CNSE to further develop high-efficiency flexible solar cells. The modules will be targeted at defence and commercial applications, making use of their significant advantages over inflexible solar cells that are made using crystalline silicon and thin film solar cells on glass.

Ashok K. Sood, President and CEO of Magnolia Solar Corporation, says, "We are working with the College of Nanoscale Science and Engineering through our research and development centre located at CNSE's Albany NanoTech Complex to further improve the PV production process and demonstrate AR coating technology on high-efficiency solar cells. We are also grateful for NYSERDA's support and for our collaboration with CNSE and the U.S. Photovoltaic Manufacturing Consortium, part of the Department of Energy's SunShot Photovoltaic Manufacturing Initiative (PVMI)."

CNSE Professor and Vice President for Clean Energy Programs Pradeep Haldar continues, "As further testament to Governor Andrew Cuomo's vision and leadership in catalysing New York's innovation-driven economy, the results of CNSE's collaboration with Magnolia Solar demonstrate a unique ability to tap the vast potential of solar energy."

He adds,"Through its leadership in PVMC, CNSE is delighted to work with companies like Magnolia Solar to lower the costs of solar energy production, making this clean energy resource even more competitive by taking advantage of New York's world-class research and development ecosystem."

Magnolia Solar has filed many patents to protect its intellectual property, and the company continues to add to its patent portfolio. The firm is also making progress with further improvements to the CIGS solar cells and nanostructured AR coating technology for solar cell applications.

This nanostructured antireflection coating uses oblique angle nanostructure growth, thereby enhancing energy absorption and minimising reflection loss.

Manz's CIGS to power up China

The solar energy project in Shilin Town in China's south western province Yunnan is currently the largest CIGS module solar park feeding power into the Chinese grid

Manz AG, is demonstrating the standards of its CIGSfab production line with the installation of thin film modules.

The modules were produced on the CIGS innovation line at the company's research site in Schwäbisch-Hall, which was taken over by Manz from Würth Solar at the start of 2012.

"Now that the Solar Park in Shilin Town has been commissioned, we can demonstrate the advantages of CIGS technology and the excellent manufacturing quality of our machines in practice. We are highly optimistic that we will also be able to convince interested solar cell producers of the benefits of our CIGSfab. Our aim in 2013 is to consistently exploit the potential that the solar market offers us," says Dieter Manz, founder and CEO of Manz.

The Manz modules installed in China have a nominal capacity of one Megawatt.

The investor is Beijing Sanglin Lantian Ltd. Co., a company which focuses among other interests on the planning and realisation of renewable energy generation projects.

Xiao-Yi Wang, President and shareholder of the Solar Park, comments, "In comparison with the crystalline solar modules already installed, the Manz CIGS solar modules yield up to 10 percent more. That is an absolutely decisive figure which underscores sustainably the immense potential of this technology and impressively demonstrates the benefits of the favourable temperature coefficients of CIGS in the almost subtropical climate of Yunnan."

Dieter Manz adds, 'In terms of efficiency, in recent months we have made a great step forward. Now, in mass production we reach more than 13 percent on a stable basis. This has so far been unequalled anywhere else in the world, and strengthens our market position to participate in the coming investment cycle in the solar industry."

Beijing Sanglin Lantian Ltd. Co has had the modules installed in the open landscape, integrated into buildings and in roof-mounted configuration.

The Chinese government, too, sees clear advantages in the use of CIGS technology which has been adopted as a focus of research in its 12th five-year plan. CIGS modules achieve a significantly higher degree of efficiency than other thin-film modules. At the same time, production costs are significantly lower than for crystalline solar cells.

The reason for this is that in the case of CIGS modules, the semiconductor layer that absorbs sunlight is in large part composed of low-cost copper and is less than two microns thick - around one hundredth of a crystalline solar cell. Producing thin film modules based on glass substrates also obviates the costly manufacture of silicon wafers, as well as the need to interconnect each individual cell.

Manz maintains its CIGSfab makes it possible to produce high-efficiency thin film modules at an economic cost. Depending on the location, thin film solar modules manufactured on the integrated CIGS production line will in future be able to supply energy at a cost of a miniscule 4 euro cents (Spain) and 8 euro cents (Germany) per kilowatt hour.

This puts solar electricity on a par with electricity generated from fossil fuels, and well below the cost of power generated by offshore wind farms. Apart from providing all the machinery, Manz also offers the know-how required for module production. And so new entrants to the solar market can rapidly ramp up local production of solar modules in the growth markets of the future.

Solar Junction commercial ready cell beats efficiency record

The manufacturer of III-V multi-junction solar cells used a Veeco MBE system to achieve critical milestones in developing a production-ready commercial cell

The world record for energy efficiency of a commercial-ready production solar cell has been achieved by Solar Junction on Veeco's Dual GEN200 MBE System.

Solar Junction, a developer of multi-junction solar energy cells for the concentrating photovoltaics (CPV) market, reported last October that the power conversion efficiency of their CPV cells was measured at a whopping 44 percent at 947 suns, as verified by the National Renewable Energy Laboratory (NREL).

Homan Yuen, Solar Junction's Vice President of Research & Development, comments, "Veeco's MBE system enables us to reach critical milestones in solar cell efficiency. Their system is instrumental in pushing the boundaries of technology to make CPV a more

competitive option for solar power."

Jim Northup, Veeco's Vice President and General Manager, adds, "We wholeheartedly congratulate Solar Junction on their world record, and are committed to supporting their new facility's production ramp. The GEN200 is the ideal pilot production tool, and we take great pride in providing the deposition platform for this ground-breaking result."

The GEN200 MBE cluster-tool design provides the material source and wafer configuration flexibility for R&D or for multi-wafer production applications. The flexibility of the cluster tool design enables the GEN200 system to deliver higher throughput and lower cost per wafer, in a footprint up to 60 percent smaller than comparable MBE systems. It can support dual growth modules, allowing facilities to either greatly increase production or grow different materials within a single, integrated system.

First Solar CdTe modules support Inner Mongolia University

The firm has donated its cadmium telluride modules as part of the biennial 2013 Solar Decathlon Competition. This contest challenges students to use a holistic approach to design and engineer houses with net-zero energy consumption

First Solar has donated its CdTe PV solar modules to a team of students from Inner Mongolia University of Technology (IMUT).

The students will use the company's advanced thin-film solar modules to power its house in the 2013 Solar Decathlon China competition.

First Solar donated 150 of its PV modules with a peak generating capacity of 13 kilowatts (kW) to IMUT's "Team Green Sun" and will provide technical support for the project team, as well as collaborating with IMUT on solar education.

This is the third time First Solar has supported the Solar Decathlon competitions.

"We are proud to support IMUT's Team Green Sun in bringing cost-effective and energy-efficient technology to the region," says Bruce Yung, First Solar's Managing Director and Vice President of Business Development for China.

"China represents a very important market for First Solar. The fact that this year's Solar Decathlon is being held here is reflective of the government's commitment to developing the solar industry to meet interlinking economic, energy and environmental goals. First Solar is very pleased to be able to contribute to China's solar development in this way," continues Yung.

Originally developed by the U.S. Department of Energy in 2002, the Solar Decathlon is a biennial competition that challenges students to use a holistic approach to design and engineer houses with net-zero energy consumption. The competition helps demonstrate that solar-powered homes are fully functional and sustainable, while promoting innovation and adoption of solar energy technologies.

This year marks the first time China has hosted the Solar Decathlon competition. It features 22 teams from around the world, with 13 teams coming from China. The 2013 Solar Decathlon China is the result of an agreement between China's National Energy Administration and the U.S. Department of Energy to encourage energy collaboration between the two countries.

"First Solar strives to give back to the communities in which we operate. We are eager to share our expertise with students in the industry around the world so that we can help cultivate new and creative ideas in our future leaders," comments Jim Brown, First Solar's Executive Vice President of Global Business Development.

"First Solar supports China's sustainable development and the Chinese government's commitment to the solar energy industry at the national and provincial levels. We hope that by participating in the Solar Decathlon competitions, we can further raise awareness about the importance of solar technologies in achieving a sustainable energy future," adds Brown.

Team Green Sun's house design for the 2013 Solar Decathlon China is based on the yurt, a tent-like habitat indigenous to Inner Mongolia and other parts of Central Asia.

The team's project seeks to address energy issues common in the region, including power grid inaccessibility, water shortages and high heating demands.

First Solar's solar modules will equip the house with an efficient source of energy that successfully addresses the energy needs of off-grid areas with challenging operating conditions. The team consists of 21 graduate and undergraduate students from various majors, including energy and power engineering, architecture, civil engineering and management.

First Solar's thin-film solar modules generate clean, renewable energy with no emissions, waste or water

consumption during operation. The company's unique cadmium telluride (CdTe) photovoltaic technology offers compelling advantages over typical silicon technology. These include superior light absorption and better performance at high temperatures.

The firm says its technology enables First Solar's modules to perform better in real-world conditions, as they are impacted less by heat, shading and soiling. First Solar claims its module production process also has the lowest carbon footprint and the shortest energy pay-back time of any current PV technologies on a life-cycle basis.

Transphorm 600 V GaN-on-Silicon devices gain JEDEC qualification

The firm believes this is a major milestone for GaN power electronics as JEDEC qualification of gallium nitride-on-silicon. It will enable mass adoption price points for devices providing dramatically improved power efficiency

Transphorm has announced its complete series of GaN on silicon transistors and diodes, are the world's first JEDEC-qualified 600V GaN device platform.

This marks a significant milestone in the broad adoption of GaN-based power electronics in power supplies and adapters, PV inverters for solar panels, motor drives, as well as power conversion for electric vehicles.

Based on Transphorm's patented EZ-GaN technology, the TPH3006PS GaN high electron mobility transistor (HEMT) combines low switching and conduction losses to reduce energy loss by 50 percent compared to conventional silicon-based power conversion designs.

The TO-220-packaged GaN transistor features low on-state resistance (RDS(on)) of 150 milliohms (mΩ), low reverse-recovery charge (Qrr) of 54 nanocoulombs (nC) and high-frequency switching capability - all of which result in more compact, lower cost systems.

Also available in industry-standard TO-220 packages, the TPS3410PK and TPS3411PK GaN diodes offer 6A and 4A operating currents, respectively, with a forward voltage of 1.3V. In addition, three application kits - PFC (TDPS400E1A7), Daughter Board (TDPS500E0A) and Motor Drive (TDMC4000E0I) - are available for rapidly benchmarking the in-circuit performance of Transphorm's products.

"Solidifying its leadership position in high-voltage GaN power conversion solutions, Transphorm has accomplished the first qualification of 600V GaN devices on silicon substrates," says Primit Parikh, President of Transphorm.

"This is critically important because it allows manufacturers to access the energy savings from our GaN transistor and diode products with the cost benefits of silicon. The introduction of the Total GaN family dispels the myth that qualification of high-voltage GaN on silicon is not possible, and enables the introduction of new power products in the marketplace that are dramatically more efficient compared to silicon-based products. Transphorm is today driving the next power standard," he continues to point out.

Transphorm's EZ-GaN platform can reduce power system size, increase energy density and deliver high efficiencies across the grid. For manufacturers looking for a low-risk roadmap to the next generation of power conversion technology, EZ-GaN provides a cost-effective, customisable and easy-to-use solution ready for commercial scale.

For approved customers, the TPH3006PS HEMT device is available for sale at a price of $5.89 each in 1,000 quantities. The TPS3410PK and TPS3411PK diodes are priced at $2.06 and $1.38, respectively, also in 1,000-piece quantities.

U.S. PVMC & and NREL to propel CIGS technology

The joint effort will enhance manufacturing and market analysis, key requirements for sustainable deployment of solar PV energy

The U.S. Photovoltaic Manufacturing Consortium (PVMC) has partnered with the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) to improve manufacturing processes for thin film CIGS photovoltaic (PV) cells and modules.

These will include products, metrology and reliability that will support the U.S. solar industry in the development, manufacturing, and commercialisation of next-generation solar PV systems.

PVMC is an industry-led collaboration headquartered in New York at the SUNY College of Nanoscale Science and Engineering (CNSE).

"In support of Governor Andrew Cuomo's innovative green energy strategy that is fuelling New York's emergence as a leader in the cleantech industry, PVMC is delighted to partner with NREL to help drive important advances in our nation's solar future," says Pradeep

Haldar, PVMC Chief Operating and Technology Officer and CNSE Vice President of Clean Energy Programs. "Through this initiative, we look forward to enhancing the manufacturability of thin film solar PV technologies, which is critical to enabling increased usage in residential, commercial and utility applications across the country."

"This unique partnership between NREL and PVMC will leverage national resources, accelerate commercialisation of next generation solar products, and boost interactions between U.S. research labs and industry manufacturing initiatives," adds Joe Hudgins, senior VP of business development and strategic alliances, PVMC.

"Together we are leading the national effort to help facilitate the transfer and commercialisation of future solar products, equipment, and manufacturing lines including thin film, advanced silicon, and future materials," continues Hudgins.

NREL is one of the world's leading renewable energy centre in many fields of photovoltaic research, and has established processes, measurement and characterization capabilities, and expertise in all the major PV conversion technologies.

PVMC will join NREL to support U.S. solar manufacturing by leveraging decades of knowledge and capabilities in materials and cell processing, advanced testing, metrology and materials analysis, and modelling. These interactions will accelerate PVMC program deliverables and help overcome the gaps and challenges necessary to build a strong U.S. solar industry.

What's more, the NREL and PVMC collaboration effort will be expanded to other national labs to create a greater impact on the U.S. PV manufacturing industry. These national partnerships replicate the successful SEMATECH and CNSE models that have regained and sustained U.S. technology leadership in the semiconductor industry for several decades.

Spearheaded by CNSE and SEMATECH as part of the U.S. Department of Energy's (DOE) SunShot Initiative, PVMC is targeting a reduction in the total installed cost of solar energy systems by 75 percent over the next decade.

As an active participant in PVMC's U.S. Thin-Films PV Roadmap, NREL is working with other roadmap members to provide a congruent plan for the national CIGS industry, including module and systems manufacturers, suppliers, and end-users, that will identify common challenges and define the areas of technical developments needed to sustain and advance a competitive U.S. photovoltaic industry.

Several initiatives are currently underway to enhance product and manufacturing development, some of which are likely to become industry standards in the future. Recently, SEMI and PVMC signed a Memorandum of Understanding to enhance their cooperation in areas of standards and roadmap activities for the solar thin film industry.

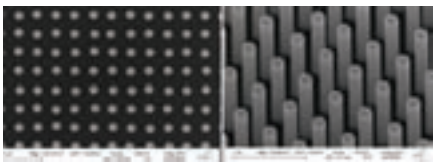
InP nanowires propel solar cells

An indium phosphide nanowire solar cell can produce an effect per active surface unit several times greater than today's silicon cells

Researchers from Lund University in Sweden have shown how InP nanowires could pave the way for more efficient and cheaper solar cells.

"Our findings are the first to show that it really is possible to use nanowires to manufacture solar cells," says Magnus Borgström, a researcher in semiconductor physics.

Research on solar cell nanowires is on the rise globally. Until now the unattained dream figure was ten per cent efficiency - but now Borgström and his colleagues are able to report an efficiency of 13.8 percent.



Characterisation of NW-array solar cells: 0° (left) and 30° (right) tilt scanning electron microscopy (SEM) images of as-grown InP NWs with a surface coverage of 12 percent

The nanowires are made of InP and work like antennae that absorb sunlight and generate power. The nanowires are assembled on surfaces of one square millimetre that each house four million nanowires.

A nanowire solar cell can produce an effect per active surface unit several times greater than today's silicon cells.

Nanowire solar cells have not yet made it beyond the laboratory, but the plan is that the technology could be used in large solar power plants in sunny regions such as the south-west of thr USA, southern Spain and Africa.

The Lund researchers have now managed to identify the ideal diameter of the nanowires and how to synthesise

them.

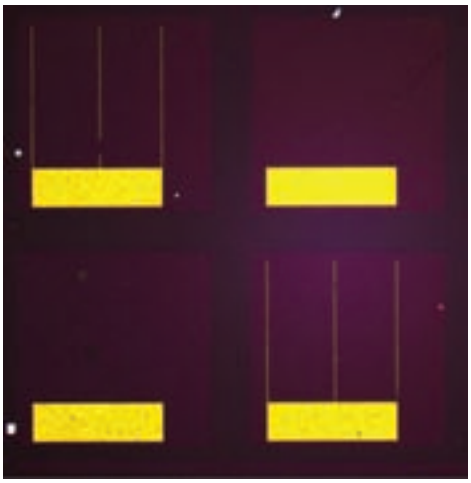
“The right size is essential for the nanowires to absorb as many photons as possible. If they are just a few tenths of a nanometre too small their function is significantly impaired,” explains Magnus Borgström.

The silicon solar cells that are used to supply electricity for domestic use are relatively cheap, but inefficient because they are only able to utilise a limited part of the effect of the sunlight. The reason is that one single material can only absorb part of the spectrum of the light.

Research carried out alongside that on nanowire technology therefore aims to combine different types of semiconductor material to make efficient use of a broader part of the solar spectrum.

The disadvantage of this is that they become extremely expensive and can therefore only be used in niche contexts, such as on satellites and military planes.

However, this is not the case with nanowires.



Optical microscope image of NW solar cells

Because of their small dimensions, the same sort of material combinations can be created with much less effort, which offers higher efficiency at a low cost.

The process is also less complicated. The researchers have shown that the nanowires can generate power at the same level as a thin film of the same material, even if they only cover around 10 per cent of the surface rather than 100 percent.

The research was carried out as part of an EU-funded project, AMON-RA, coordinated by Knut Deppert, Professor of Physics at Lund University.

“As the coordinator of the project, I am very proud of such a great result - it has well exceeded our expectations. We will of course continue the research on nanowire solar cells and hope to achieve an even higher level of efficiency than the 13.8 per cent that we have now reported,” concludes Knut Deppert.

Further details of this work have been published in the paper, “ InP Nanowire Array Solar Cells Achieving *13.8% Efficiency by Exceeding the Ray Optics Limit,” by M. Borgström et alinScience1230969.* DOI:10.1126/science.1230969

Power Electronics

EPC upgrades development board featuring eGaN FETs

The EPC9005 demonstrates the ease of designing with eGaN FETs with ready-made, easy to connect development boards. The board features a dedicated gallium nitride FET gate driver from Texas Instruments

Efficient Power Conversion Corporation (EPC) has announced the availability of the EPC9005 development board, featuring EPC’s enhancement-mode GaN (eGaN) field effect transistors (FETs).

This board demonstrates how IC gate drivers, optimised for eGaN FETs, make the task of transitioning from silicon to eGaN technology simple and cost effective.

The EPC9005 development board is a half bridge configuration containing two 40 V EPC2014 eGaN FETs with a 7 A maximum output current using a gate driver optimized for GaN devices, the LM5113 from Texas Instruments.

The LM5113 used on this board is packaged in a 2x2 BGA package allowing for a very compact power stage with the driver and two eGaN FETs. The EPC2014 is designed for use in applications such as high-speed DC-DC power supplies, point-of-load converters, wireless charging, and high frequency circuits.

The EPC9005 simplifies the evaluation process of eGaN FETs by including all the critical components on single 2” x 1.5” boards that can be easily connected into any existing converter. In addition, there are various probe points on the board to facilitate simple waveform measurement and efficiency calculation. A Quick Start Guide is included with the development board for

reference and ease of use.

EPC9005 is priced at $99.18 and, like all EPC products, is available for immediate delivery from Digi-Key at http://digikey.com/Suppliers/us/Efficient-Power-Conversion.page?lang=en.

Nitronex appoints new Engineering VP

The GaN (gallium nitride) power device RF designer and manufacturer for the defence, communications, broadband, and industrial & scientific markets is to diversify

Nitronex has named David W. Runton as its new Vice President of Engineering.

Runton has almost 20 years of RF power semiconductor experience with six years in GaN specific product development, including design, assembly, qualification and packaging.

“I’m looking forward to working with the engineering team to develop many new successful GaN products. Nitronex has very compelling technology that I feel has advantages for numerous market applications,” says David Runton. “I am joining Nitronex at an exciting time with a new owner, management team, and significant growth plans for the future.”

Runton most recently served as Director of High Power Engineering for RFMD where he led an engineering product release team and developed long term product strategy. He has also held engineering leadership positions at Freescale and Motorola Semiconductor.

“David is an excellent addition to our management team and I’m confident he will help us leverage our core technology in the RF power market. He has an extensive background developing LDMOS and GaN power devices and a proven track record leading engineering teams to develop new products and technologies,” says Greg Baker, President and CEO.

Runton holds a Bachelor Degree and a Master of Science degree in Electrical Engineering from the Georgia Institute of Technology and a Masters in Business Administration, High Technology Program from Arizona State University.

GeneSiC raises the bar in high frequency and temperature applications

The silicon carbide junction transistors will increase conversion efficiency and reduce the size, weight and volume of power electronics

GeneSiC Semiconductor, a pioneer and global supplier of a broad range of SiC power semiconductors has announces the immediate availability of a family of 1700V and 1200V SiC Junction Transistors.

GeneSiC silicon carbide junction transistor

Incorporating high voltage, high frequency and high-temperature capablability, the SiC Junction Transistors will increase conversion efficiency and reduce the size/weight/volume of power electronics.

These devices are targeted for use in a wide variety of applications including server, telecom and networking power supplies, uninterruptable power supplies, solar inverters, industrial motor control systems, and downhole applications.

Junction Transistors offered by GeneSiC exhibit ultra-fast switching capability, a square reverse biased safe operation area (RBSOA), as well as temperature-independent transient energy losses and switching times.

These switches are gate-oxide free, normally-off, exhibit positive temperature co-efficient of on-resistance, and are capable of being driven by commercial, commonly available 15V IGBT gate drivers, unlike other SiC switches.

While offering compatibility with SiC JFET drivers, Junction Transistors can be easily paralleled because of their matching transient characteristics.

“As power system designers continue to push the limits of operating frequency, while still demanding high circuit efficiencies, they need SiC switches which can offer

a standard of performance and production uniformity. Utilising the unique device and fabrication innovations, GeneSiC's Transistor products help designers achieve all that in a more robust solution," says Ranbir Singh, President of GeneSiC Semiconductor.

The 1700V junction transistors come in 110 mΩ (milliOhms) (GA16JT17-247), the 250 mΩ (GA08JT17-247) and the 500 mΩ (GA04JT17-247).

There are two new offerings in the 1200 V junction transistors ; the 220 mΩ (GA06JT12-247) and the 460 mΩ (GA03JT12-247).

All these devices have a Tjmax of 175oC and the turn On/Off have typical rise and fall times of less than 50 nanoseconds.

All devices are 100 percent tested to full voltage/current ratings and housed in Halogen-Free, RoHS compliant TO-247 packages. The devices are immediately available from GeneSiC's Authorised Distributors.

Mitsubishi Electric steams ahead with first SiC device for trains

The silicon carbide modules will be incorporated in type 1000 railcars of the Tokyo Metro Ginza Line

Mitsubishi Electric has commercialised and delivered railcar auxiliary power supply systems that incorporate what it says is the world's first SiC power modules for use in operating trains.

Systems now being installed for test operation in new Type 1000 railcars of Tokyo Metro's Ginza Line subway are scheduled to enter commercial operation in June.

Auxiliary power supply systems provide electricity to air conditioners and lighting inside railcars.

Compared to Mitsubishi Electric's existing system incorporating silicon power modules, the new system achieves 30 percent less power loss, is 20 percent smaller and 15 percent lighter. It also reduces transformer noise by 4dB due to a 35 percent improvement in the distortion rate of output voltage waveforms.

Compared to silicon, SiC helps to reduce size and weight through lowered power loss and higher energy efficiency, as well as smaller power module radiators.

Mitsubishi Electric has developed a variety of SiC power module applications, including the first large-voltage SiC railcar inverters for DC600V/750V power lines, which were launched in October 2011 and incorporated in Tokyo Metro's Ginza Line Type 01 railcars in February 2012.

Also, SiC railcar inverters developed for DC1500V power lines were launched in November 2012 and installed in Tokyo Metro's Tozai Line Type 15000 railcars beginning in January 2013.

The new SiC auxiliary power supply system incorporates technologies Mitsubishi Electric developed for SiC inverters.

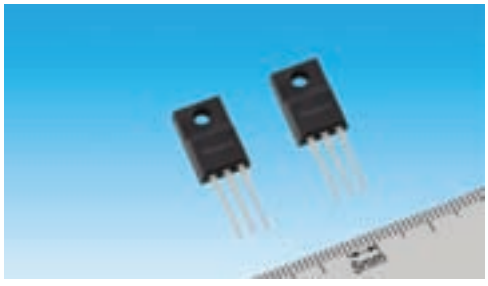
The company is also developing total railway energy solutions for enhanced energy management of railcars, including the new SiC auxiliary power supply systems, as well as stations, rail yards and train lines.

Panasonic 600V GaN power transistor is ultra stable

The company's gallium nitride transistors contribute to saving energy and are more compact than other similar devices. They are also suited to a variety of power switching systems for industrial and consumer applications

Panasonic has developed a GaN-based power transistor with a blocking voltage of 600V, which enables stable switching operations.

The company started the shipment of evaluation samples in March, 2013 and says failure-free operations of its 600V GaN power transistors have been confirmed for the first time.



Panasonic 600V transistors

These transistors have three main features.

The first is normally-off gate injection transistor on a 6-inch silicon substrate.

Power switching systems require normally-off operations

of the transistors for safe operations.
Lowering the cost of the substrate is also a major bonus for the GaN transistors to be practically used. Panasonic has solved these issues by its novel normally-off Gate Injection Transistors (GITs) on silicon substrates.The firm's proprietary technologies for the epitaxial growth of GaN by MOCVD enables the fabrication of GaN transistors on a 6 inch silicon substrate.
The *p*-type gate of the GIT greatly helps to reduce the on-state resistance taking advantages of the conductivity modulation by the hole injection from it.

The second benefit is that stable switching operation is free from what is known as "current collapse."

So far, the increase of the on-state resistance after the application of high voltage, or current collapse, has been a serious problem for the commercialisation of GaN transistors. Panasonic says the increase of the on-state resistance is the greatest obstacle to achieve the stable operations of the transistors. The origin of the collapse is believed to be trapped electrons under a high electric field. The firm also says that it reduces the number of the traps by its novel processing technologies, in addition to new device structures relieving the electric field. The fabricated GIT on silicon enables stable 600V operations free from the current collapse.

The final advantage is that the structure enables highly efficient switching at high frequencies.

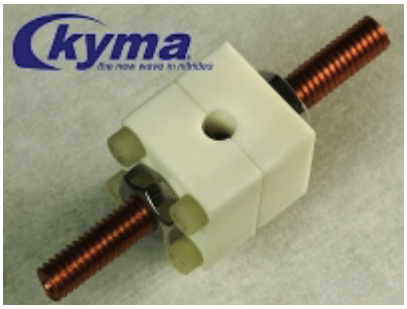
The lateral structure of the GIT is better for high speed switching owing to the lower parasitic capacitance than that in conventional silicon-based power transistors with the vertical structures.
Here, RonQg (Ron: on-state resistance, Qg: gate charge) is a figure-of-merit for high speed switching. The fabricated GIT exhibits a RonQg one thirteenth lower than that by the state-of-the-art silicon MOS transistors indicating the superior potential. Panasonic also demonstrate 1MHz operation of resonant LLC DC-DC converters at high efficiency over 96 percent by using the GITs on silicon. This demonstration indicates that the presented GIT on silicon can be used for practical systems free from operation failure.

You can rely on Kyma's first III-nitride power device

The supplier of crystalline aluminium and gallium nitride materials found that there is no noticeable degradation in the on resistance of its KO-Switch after 1 million device operations

Kyma Technologies has completed its initial investigation of the device reliability of its recently launched KO-Switch.

The company first announced the launch of the KO-Switch as its first device product in September last year.



KO-Switch

The module was realised from an Air Force Research Laboratory (AFRL) R&D investment managed by John Blevins of AFRL and led by Bob Metzger, Kyma's Chief Technology Officer.

Characteristics of the device operation were presented last month at Photonics West 2013 by Jacob Leach, Kyma's Chief Science Officer.

Kyma also conducted tests to see how stable the KO-Switch was by measuring its performance under various device operating conditions.

Many of the applications that the KO-Switch is being considered for require impedance matching at the 50Ω resistance level. Hence Kyma operated the KO-Switch under conditions that target an on-resistance (RON) of 50Ω and see if the RON drifted over time or as a function of another variable such as operating temperature.

The fast switching speed of the KO-Switch will really benefit many applications if the device can be switched on and off thousands or even millions of times without significant degradation.

Taking that in mind, Leach and Metzger designed a test to repeatedly turn the KO-Switch on and off over 1,000,000 times while monitoring RON and measuring the current through the device, which was biased at 1,000 volts (in the off condition).

The 532nm excitation laser was adjusted to excite the device with 5ns wide pulses in a 10Hz pulse train and was coupled to the device to set the initial RON to 50 Ω. Instantaneous current passing through the 2mm diameter device was 50A while the switch was closed.

After subjecting the switch to over 1,000,000 close/open cycles, the change in RON was less than 1 percent, which is within the error of the measurement system. So, Kyma asserts there was no noticeable degradation in RON after 1,000,000 device operations.

Leach comments, "We are very encouraged at the

excellent reliability we find under these operating conditions, which are relevant for several different customer applications. Next we want to begin pushing the device harder, at higher currents and laser pulse energies, for example, and under higher bias voltage. I am confident we will find the edges of its reliability behaviour which will inform our future device improvement plans."

Metzger adds, "We believe these are the first publically disclosed device reliability results obtained on a wide bandgap photoconductive switch. This is an exciting new product space for us to get involved in and we look forward to seeing how far we can take the switch in terms of high performance applications."

Leach and Metzger are in the process of preparing a scientific publication that will describe the details of the device reliability study.

Kyma has already sold several units of the KO-Switch this year and is working with a number of large companies to understand its potential to support several high performance high power switching applications.

According to Kyma, the market for nitride semiconductor devices was roughly $10 billion in 2012 and is expected to surpass $60 billion over the long term, including $30 billion in visible lighting applications and $30 billion in power electronics applications.

First mass-produced SiC module without a Schottky diode

Japanese firm Rohm has reduced power loss in its new silicon carbide device, making it ideal for 1200V/180A inverters

Rohm has started mass-production of a 1200V/180A-rated SiC MOS module BSM180D12P2C101 for inverters/converters used in industrial equipment, photovoltaic power conditioners and the like.

BSM180D12P2C101

The firm says this new module is the first to incorporate a power semiconductor comprised of just a SiC MOSFET, increasing the rated current to 180A for broader applicability while contributing to lower power consumption and greater compactness.

Next-generation SiC MOSFET technology minimises conduction degradation of the body diode, eliminating the need for diode rectification. This makes it possible to increase the mounting area for higher current handling capability while maintaining the same compact form factor.

What's more, by improving processes and device structures related to crystal defects Rohm was able to overcome all problems related to reliability, including that of the body diode.

Switching characteristics are maintained using a simple MOS structure without a Schottky Barrier Diode. And unlike silicon IGBTs used in general-purpose inverters, no tail current is generated, reducing loss by more than 50 percent.

Also, switching frequencies over 50kHz are supported, which Rohm says is impossible with silicon IGBTs. This contributes to smaller, lighter peripheral devices.

General-purpose silicon IGBT devices are not capable of conduction in the reverse direction.

In contrast, the body diode in Rohm's SiC MOSFET always conducts in reverse. And depending on the Gate signal input the MOSFET can operate in either direction for lower ON resistance or using just the diode. These reverse direction conduction characteristics enable a high efficiency synchronous rectification in the 1000V range - higher than diode rectification.

Another positive is that clarifying the mechanism by which defects are spread based on body diode conduction makes it possible to minimise the primary factors through process and device construction.

With general-purpose products the ON resistance increases significantly after 20 hours. In contrast, Rohm says its new module ensures no ON resistance increases - even after more than 1000 hours.

Cree Announces Volume Production of Second-Generation SiC MOSFET

New Devices Could Deliver Significant Cost Savings to Power-Conversion Systems

Cree, Inc. has announced the release of its second generation SiC MOSFET enabling systems to have higher efficiency and smaller size at cost parity with silicon-based solutions. These new 1200V MOSFETs deliver industry-leading power density and switching efficiency at half the cost per amp of Cree's previous generation MOSFETs. At this price-performance point, they enable lower system costs for OEMs and provide additional savings to the end-user through increased efficiency and lower installation costs due to the lower size and weight of SiC-based systems.

"We have evaluated Cree's second generation SiC MOSFET in our advanced solar circuits," stated Prof. Dr. Bruno Burger, renowned industry expert at the Fraunhofer-Institute in Freiburg, Germany. "They have state-of-the-art efficiency and enable system operation at higher switching frequencies that result in smaller passive components, especially smaller inductors. This substantially improves the cost-performance trade off in solar inverters in favour of smaller, lighter and more efficient systems."

The superior performance of these new SiC MOSFETs enables the reduction of required current rating by 50-70 percent in some high power applications. When properly optimized, customers can now get the performance benefits of SiC with the same or lower systems cost as with previous silicon solutions. For solar inverters and uninterruptible power supply (UPS) systems, the efficiency improvement is accompanied by size and weight reductions. In motor drive applications the power density can be more than doubled while increasing efficiency and providing up to twice the maximum torque of similarly rated silicon solutions. The product offering range has been extended to include a much larger 25 mOhm die aimed at the higher power module market for power levels above 30 kW. The 80 mOhm device is intended as a lower cost, higher performance upgrade to the first generation MOSFET.

"With our new MOSFET platform, we already have design wins in multiple segments," explained Cengiz Balkas, vice president and general manager, Cree Power and RF. "Due to the rapid acceptance of this second generation of SiC MOSFETs, we are shipping pre-production volumes to several customers ahead of schedule and we are ramping volume production in-line with customer demand."

Die are available with ratings of 25 mOhms, intended as a 50 Amp building block for high power modules, and 80 mOhm. The 80 mOhm MOSFET in a TO-247 package is intended as a higher performance, lower cost replacement for Cree's first-generation CMF20120D. Packaged parts are available immediately from DigiKey, Mouser and Farnell.

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EPC unveils development board featuring 100V eGaN FETs

The development board features a dedicated gallium nitride driver to facilitate the rapid design of high frequency switching power conversion systems using the EPC2016 eGaN FET

Efficient Power Conversion Corporation (EPC) has introduced the EPC9010 development board to make it easier for engineers to start designing with a 100V enhancement-mode GaN (eGaN) field effect transistor (FET).

Relevant applications include high-speed DC-DC power supplies, point-of-load converters, class D audio amplifiers, hard-switched and high frequency circuits.

The EPC9010 development board has a 100V maximum device voltage, 7A maximum output current and half bridge with onboard gate drives, featuring the EPC2016 eGaN FET.

The purpose of this development board is to simplify the evaluation process of eGaN FETs by including all the critical components on a single board that can be easily connected into any existing converter.

The EPC9010 development board is 2" x 1.5" and contains two EPC2016 eGaN FETs in a half bridge configuration using the LM5113 gate driver from Texas Instruments, as well as supply and bypass capacitors.

The board contains all critical components and layout for optimal switching performance. There are also various probe points to facilitate simple waveform measurement and efficiency calculation.

The EPC9010 development boards are priced at $99.00 each and are available for immediate delivery from the Digi-Key website.

Transphorm transcends to 200mm with Aixtron GaN-on-Si reactor

The AIX G5+ system will be used to grow gallium nitride on silicon for power supplies, PV inverters/power conditioners, motor drives, and electric vehicles

US company Transphorm Inc. is stepping up production of GaN-on-Si with its latest order of Aixtron's G5+ MOCVD system, capable of handling five 200mm (5 x 8 inch) wafers.

AIX G5+ MOCVD system (for 5 x 8 inch 200mm wafers)

The order was made in the fourth quarter of 2012 with delivery due in the second quarter of 2013.

Primit Parikh, President of Transphorm says, "We are not just increasing our capacity with this order. This new system also expands our capability from 150mm to 200mm diameter wafers, providing economies of scale. We are projecting lower costs of ownership with larger wafer diameters, allowing us to bring this transformative technology into much wider use."

Frank Wischmeyer, Vice President and Program Manager Power Electronics at Aixtron, adds, "When we developed the Aixtron G5+ system we had customers like Transphorm in mind. GaN-on-Si is rapidly developing and the industry expects commercial products in the near future. In order to be successful, GaN-on-Si needs to deliver the highest quality at the lowest cost of ownership. We have developed the G5+ to deliver

extremely stable, uniform processing on multiple large diameter wafer runs."

Transphorm ordered its first Aixtron system in 2010, an AIX 2800G4 HT system in a 6 x 150mm wafer configuration. Parikh adds, "Due to the performance of our existing system, we expect to be able to scale up to the larger diameter wafers smoothly and quickly."

The AIX G5+ is based on the AIX G5 HT reactor platform. The stability and uniformity of results in this system enable higher device yields than for any other MOCVD platform on the market.

Transphorm says it is redefining electric power conversion, providing easy-to-embed power conversion devices and modules that reduce costly energy loss by more than 50 percent; at an affordable system cost. The firm believes its GaN based solutions simplify the design and manufacturing of power supplies, PV inverters/power conditioners, motor drives, and electric vehicles.

TriQuint announces inducement equity grants

The grant was undertaken under NASDAQ Marketplace Rule 5635

The Compensation Committee of TriQuint's Board of Directors approved a stock option award for an aggregate of 150,000 shares of the company's common stock under the company's 2008 Inducement Award Program to one new employee.

The stock option grant was effective March 7th, 2013.

The options will vest 25 percent on March 7th, 2014 with the remaining 75 percent vesting quarterly over the next three years, and have an exercise price of $4.58, which was the closing price of TriQuint's common stock on March 7th, 2013. The option grant expires on March 7th, 2023.

TriQuint's Compensation Committee, which is solely comprised of independent directors, approved the grant of the stock options on February 13th, 2013 in accordance with NASDAQ Listing Standard 5635(c)(4).

Equipment and Materials

Flow mode DLS shows promise for in-line slurry particle sizing characterisation

Research engineers and scientists at Mega Fluid Systems are investigating Malvern Instruments flow mode DLS technology and developing new methods for CMP slurry.

Koh Murai, VP of Engineering, presented the initial results at the Levitronix 29th European CMP Users Meeting in Zurich, Switzerland. The main objective of the work is to determine feasibility of using flow mode DLS for in-line characterisation of CMP slurry.

The presentation covers methods and apparatus, range of application flow rates, precision, and impact of heating due to extensive recirculation. Key conclusions are flow mode DLS which is promising for in-line slurry particle sizing, and extensive recirculation did not result in measurable changes in mean particle size.

"We are very happy to take an active role in embedding leading-edge technologies, such as Malvern Instruments, into advanced particle measurement techniques critical to the CMP industry," says Jack McCann, Mega Fluid System's President. "It is yet another indication that Mega is committed to furthering our leadership position as the world's superior resource for slurry blend and delivery equipment."

Mega continues to work on challenges of flow control and accuracy of flow mode DLS.

The new method is expected to provide a platform for in-line, high precision characterisation of particle size distribution over the range 5 to 500nm featuring= chemical and slurry blend and delivery equipment to the global semiconductor, LED, pharmaceutical, specialty chemicals, and solar/PV industries.

Saint-Gobain Introduces Welding Tool

The high-speed beadless fusion system for non-metallic piping features SIB technology

Saint-Gobain Performance Plastics has introduced a new Sani-Tech SIB3 high-speed fusion welding tool for the fabrication and installation of high purity water piping systems.

Sani-Tech high-purity piping is used in the delivery of highly purified water including USP purified, USP WFI, and RO/DI. Saint-Gobain says the compact SIB 3 is reliable, lightweight and easy to operate. It performs beadless welds in a fraction of the time and labour required by other available systems.

The SIB 3 is engineered to join either Sani-Pro K PVDF or Sani-Pro T polypropylene. Both of these high-purity materials meet or exceed USP Class VI and FDA 21 CFR 177.2510 or CFR 177.1520.

Saint-Gobain's SIB (smooth inner bore) technology features a smooth inner surface free of weld beads, crevices or intrusions and eliminates areas of particle entrapment and flow restriction.

Sani-Pro K accommodates operating temperatures up to 80°C (175°F) and is suited to semiconductor and other applications.

The PC-based SIB 3 system allows users to store and print weld cycle data for piping system validation. The programmed weld cycles are activated through a simple, easy-to-read touch screen.

The lightweight, remote weld head enables welds to be made in limited access locations such as overhead installations. Cost-effective installation now enables systems owners to take full advantage of all the benefits of a non-metallic piping system, including reduced labour costs, maintenance costs and downtime.

StellarNet's spectrometer analyses LED, solar & laser products

The compact versatile system has 1nm resolution and 25µm slit and is suited to portable, process, or laboratory environments

StellarNet has released a new high performance spectrometer called the SILVER-Nova.

It has a ruggedised metal enclosure with a fibre optic input for demanding applications in the 190-1110nm wavelength range that require high resolution and optimal sensitivity over a wide spectral range.

SILVER-Nova spectrometer

The SILVER-Nova is a well rounded spectrometer and allows research grade results for numerous spectroscopic applications. These include measurements such as reflectance, absorbance and fluorescence. Materials which can be analysed include LEDs, solar cells and lasers.

The spectrograph employs composite grating technology to deliver high efficiency in both the UV & NIR spectral extremes.

The UV enhanced CCD detector with integrated TE cooler, gain enhancements, and optical lens assemblies allow for unparalleled sensitivity, with over 65 percent increased signal to noise at long exposures. Advancements in SILVER-Nova optical design deliver 1nm resolution with a 25µm slit. What's more, the compact metal enclosure allows for portable, process, or laboratory environments.

GT appoints new VP for business development

The latest addition to the team will initially concentrate on the firm's ASF equipment business. The firm's sapphire furnaces are popular with LED manufacturers

GT Advanced Technologies has taken on Linda Reinhard as vice president, new business development and product management for the company's sapphire, DSS and HiCz products.

Reinhard will report to Dan Squiller, GT's chief operating officer.

She will be responsible for leading GT's growth into new market segments and driving the product roadmap to capitalise on these new opportunities including sapphire for cover and touch screen applications.

"Linda brings deep experience and a proven track record in both product management and new business development," says Dan Squiller, GT's chief operating officer. "Linda's initial focus will be on growing our sapphire material and ASF equipment business, particularly new opportunities in the cover and touch screen markets. She has extensive experience in Asia as well as in the mobile device segment which we believe could be a significant area of opportunity for our sapphire business. Linda will also drive our product management and new business development for HiCz and our traditional PV business."

GT's Advanced Sapphire Growth Furnaces (ASF) is a production proven furnace that produces high quality sapphire material for the LED industry.

Reinhard received her BSEE from University of Illinois and an MBA from The Kellogg Graduate School of Management. She has over 20 years of experience with leading technology companies including Motorola, Cisco, Nokia, and H-P holding senior level positions in new business development, marketing, sales, and product management. She has lived in Asia and has extensive experience in China and Asia Pacific introducing new products to major OEMs.

Reinhard will be located in GT's headquarters in Merrimack, New Hampshire.

"Our goal for the show is to continue educating the market about the unique properties of GT's ASF-grown sapphire material for cover and touch screen applications," says Linda Reinhard, GT's vice president of business development and product management.

"ASF-grown sapphire's durability and resistance to scratching makes it ideally suited for a wide range of cover and touch screen applications from ruggedised phones, camera covers, point of sale devices and smartphone and touch screen devices. Other reinforced glass and cover screen technologies try to emulate what ASF-grown sapphire does naturally."

GT Advanced Technologies Inc. is a global provider of sapphire crystalline growth systems and materials for the solar, LED and other specialty markets. The company says its products and services allow its customers to optimise their manufacturing environments and lower their cost of ownership.

CVD Equipment sells off former corporate HQ

The aim of the sale was to generate funds to increase sales and operations in the company's new 130,000 square foot manufacturing facility

On April 5th, 2013 CVD Equipment Corporation completed the sale of its 50,000 square foot facility located at 1860 Smithtown Avenue, Ronkonkoma, New York where its former corporate headquarters had been located.

The sale price of the premises was $3,875,000, representing an estimated profit of approximately $900,000 to CVD.

Leonard Rosenbaum, President and Chief Executive Officer comments, "The sale closes a chapter of our company's history and highlights a new chapter as our attention and efforts are focused towards increased sales and operations in our new 130,000 square foot facility where we will be expanding our i) Equipment manufacturing and Nano material manufacturing capabilities, ii) Pilot production process development and demonstration for the transformation of nano materials to macro sized materials and iii) Joint business/technology developments for products enabled by nano materials to be marketed through our wholly owned subsidiary, CVD Materials Corporation."

CVD Equipment Corporation) is a designer and manufacturer of customised and standard equipment used in the development, design and manufacture of advanced electronic components, materials and coatings for research and industrial applications. The firm's CVD, deposition, gas control, and other equipment is used in the growth of many materials and devices including LEDs, solar cells and III-V nanowires.

Oxford Instruments to hold Nanoscale seminars in Far East

Subjects to be discussed at the plasma processing seminars in Beijing and Taiwan include III-nitride HBLEDs, SiC power devices and Atomic Layer Deposition

Oxford Instruments, a manufacturer of plasma etch and deposition systems, will be holding two one day Seminars in Asia focussing on Nanoscale Plasma Processing.

These events are being held on the 14th May (Beijing, China) and 16th May (ITRI, Hsinchu, Taiwan).

Previous Oxford Instruments seminar in China

They will feature talks by a number of invited guest speakers, specialists from China, Taiwan and Europe, in addition to Process and Applications experts from Oxford Instruments Plasma Technology.

These academic and industrial experts will discuss topics including Atomic Layer Deposition (ALD), Photovoltaics (PV), Deep Silicon Etch, Power Devices, HBLED and Ion Beam technologies during the full one day programme.

Yang Fuhua, a professor at the Institute of Semiconductors, CAS, Beijing is very pleased to be involved with the Beijing seminar. “We hosted a similar event with Oxford Instruments two years ago and it was a great success with attendance of over 100 people. The content was excellent with very informative talks from a diverse range of speakers. The events are a great means of finding out about new techniques in an informal setting, with plenty of time to speak to the experts!” he exclaims.

Jeffrey Seah, Asia Business Manager for Oxford Instruments Plasma Technology, who will open the Seminar comments, “We are anticipating a large audience at these Seminars in China and Taiwan, and are extremely honoured that so many distinguished speakers have accepted our invitation to speak about their work in Plasma Processing. Our Seminars are a great opportunity for the Plasma Processing community to come together, to share their experiences, and to learn more from leading international experts in their field.”

Based on the success of their previous Seminars in Beijing and Shanghai, Oxford Instruments anticipates a very high level of interest from both academic and production participants, attracted by such an interesting programme and prestigious speakers.

The event is free to attend, but booking is essential via process.news@oxinst.com, lingling.wang@oxinst.com (Beijing seminar) or Maggie.tsai@oxinst.com (ITRI, Taiwan seminar)

Aixtron proposes two candidates for election to Supervisory Board

Both Ph.D. candidates are experienced in sectors relevant to MOCVD equipment manufacturer Aixtron

The Supervisory Board for Aixtron SE has proposed Andreas Biagosch and Martin Komischke as candidates for election to its Supervisory Board at the upcoming 2013 Annual General Meeting.

Biagosch worked for 28 years as an engineer for the international consulting firm McKinsey & Co. on various international projects for high-tech and other industries and was part of McKinsey’s global Shareholder Council. He currently works as an independent entrepreneur.

Komischke, who is also an engineer, is currently Chairman of the Executive Board at Hoerbiger Holding AG, a manufacturer of performance-defining components for mechanical engineering in Switzerland.

Both candidates have a wealth of experience in sectors relevant to Aixtron. Their professional experience in consultancy and industry, alongside the knowledge and vocations of the full Supervisory Board, were important factors in the decision to select and recommend these individuals.

The Supervisory Board is following the recommendation of the Nomination Committee and proposes both candidates to its shareholders for election at the Annual General Meeting to be held in Aachen on May 23rd, 2013.

Holger Jürgensen has been appointed Honorary Chairman of the Aixtron Supervisory Board. Jürgensen, who co-founded Aixtron in 1983, ran the company and served on its Board of Directors until 2002. Between 2002 and 2013, he was Deputy Chairman of the Aixtron Supervisory Board. Jürgensen resigned in January 2013 for personal reasons. In recognition of his work over the last 30 years and his service to the company, the Supervisory Board has decided to appoint him Honorary Chairman.

UPRtek measures illuminance and chromaticity of LEDs

The firm's compact spectro-radiometer measures illuminance and enables an evaluation of LEDs in terms of colour performance for sorting and binning tasks during manufacturing

The robust and reliable spectro-radiometer MK-350 was conceived by UPRtek as a cost-effective, mobile precision tool to measure, analyse and store the most important photometric parameters in the specification and qualification of LED, OLED and EL lamps and other luminares.

MK-350 LED meter

The MK-350 is well suited for field use in the light design of studios and workplaces, as well as in research and development. Distributor for Central Europe is Saleslink GmbH in Udenheim, Germany.

The system is based on a high-resolution (1 nm) linear CMOS sensor (receptor diameter 6.6mm) and an advanced spectroscopic architecture with embedded processor. Its spectral half-bandwidth is specified to approximately 12 nm. The compact (144 mm x 78 mm x 24 mm) and lightweight (250 g) instrument operates on rechargeable battery power. It performs an automatic dark calibration every time it is switched on.

The MK-350 measurement results are instantly displayed in its 3.5-inch LCD colour screen (320 x 240 pixels), which also serves as a convenient touch control interface. The instrument offers four basic operational modes:

"Basic" indicates the numeric value of the measured illuminance between 70 and 70,000 lux, the correlated colour temperature (CCT) in Kelvin, the standardised colour rendering index (CRI) expressed as Ra value (average of the first eight test colours) and the peak wavelength of the light source's radiated spectrum in nm.

In the second measuring mode, "Spectrum", the MK-350 displays a detailed graph of the spectral energy distribution in the radiated wavelength bands (between 360 and 750 nm) according to the measurement distance. Integration time is adjusted automatically or manually between 8 and 1000 ms.

UPRtek MK-250 LED meter in "Specrum" mode

The other two MK-350 operational modes, "CIE1931" and "CIE1976", provide the CIE chromaticity coordinates x and y, respectively u' and v', within their standardised CIE colour space diagrams.

Together with the measured illuminance, this enables an evaluation of LEDs in terms of their perceptional colour performance for sorting and binning tasks during manufacturing or in the field.

The MK-350 measures illuminance at an accuracy of +5 percent. Colour temperature is determined within +2 percent. Colour accuracy (according to CIE1931) is +0,0025, at a repeatability of +0,0005, both measured at 20,000 lux and 2856 K. CRI accuracy expressed as Ra is determined within +1.5 percent.

Measurement is initiated by touch control, either as one-time or continuous capture at selectable intervals. All measurement data (up to 2,000 files) are stored on an optional 2 GB SD-Card in an Excel- or bmp-compatible format.

A USB2.0 port enables easy data transfer. The built-in Li-Ion battery (3.7 V/ 2.5 Ah) ensures 5 hours of operation time. Operating temperature is 0 to 35 °C. Menu languages are Chinese (traditional and simplified) or English, with a German version downloadable shortly.

Henniker reveals tool for thickness control

The system provides a direct display and control of film thickness, deposition rate and frequency value for up to 6 independent deposition sources such as metal organics

The all TMC13 Deposition Rate Controller from Henniker Scientific is a versatile, multi-channel device for control of film thickness and rate in vacuum based thin film deposition processes.

TMC13 Deposition Rate Controller

The feature-rich touch-screen interface is easily customised to suit a particular operator preference and can be operated in both automatic and manual modes, providing a direct display and control of film thickness, deposition rate and frequency value for up to 6 independent deposition sources.

The device also includes shutter relays for each channel, two trip inputs for connection of pressure gauges, and two re-transmission analogue outputs as standard, as well as an extensive and fully editable materials library.

A new video driver facility allows Original Equipment Manufacturers (OEMs) to upload Service and Maintenance Procedures as video files for easy access and viewing direct from the device display.

TM13 Thickness Monitor

The Pennsylvania based manufacturer of compounds including metal-organics used in MOCVD growth has made a number of new appointments and promotions to support its growth

Greg Hertenberger has joined Gelest as Product Manager Silanes and Metal-Organics. His responsibilities include development of new business for Gelest's s greatly expanded range of metal-organic compounds used in compound semiconductor growth.

Greg Hertenberger

Hertenberger brings more than 30 years of experience in additives for coatings and construction products, including silanes and biocides, which he gained from serving in key technical, commercial and management positions with Petrarch Systems, Huls America, Degussa, International Specialty Products, and Ashland Specialty Ingredients. In addition, Hertenberger earned a Bachelor of Arts degree in Chemistry from Ursinus College and a Master of Business Administration degree from Rider University.

Matthew Suits has joined Gelest as Facilities Manager. His responsibilities include managing new construction for Gelest as well as its maintenance department. Previously, he was an Engineering and Process Manager at PB Leiner Gelatins in Davenport, Iowa, a position to which he was promoted from Maintenance and Project Engineer. Prior to that, he served in a variety of engineering positions at Dow Corning, General Electric and Louisville Gas and Electric. Suits earned a Master of Chemical Engineering degree from the University of Louisville.

Matthew Suits

Sean Nichols has joined Gelest as Purchasing Manager, responsible for the procurement of raw materials for Gelest's manufacturing operations. He came to the company following a five-year tenure as Operations Manager in the manufacturing division of Haas Group International, based in West Chester, Pa. Prior to his promotion to Operations Manager, Nichols worked as an R&D Chemist and as a Purchasing Manager. He achieved Certified Purchasing Manager status in 2001, and completed the Dale Carnegie Leadership Training for Managers program in 2004. In addition, Nichols earned a Bachelor of Science degree in Chemistry from the University of Bridgeport.

Sean Nichols

Adrien Salomon has been promoted to Production Manager, with responsibility for managing day-to-day production activities and staff. He joined Gelest in 2004 as a Chemist after earning a Bachelor of Science degree in Chemical Engineering from the University of Delaware. Since joining Gelest, Salomon has assumed positions of increased responsibility ranging from Process Engineer to Process and Development Engineering Manager.

Adrien Salomon

William Fry, who came to Gelest in 2010 as Assistant Controller, has been promoted to Controller. Prior to joining Gelest, he gained considerable experience in the auditing of manufacturing, distribution, construction, and not-for-profit organizations as a Senior Accountant for several accounting firms. A graduate of West Chester University with a Bachelor of Science degree in Accounting, Fry holds a Certified Public Accounting license from the State of Pennsylvania.

William Fry

Greg Vuk, who started with Gelest as a packer in 1999, has been promoted to Logistics Manager. Since joining Gelest, he has taken on positions of increased responsibility, including laboratory assistant, shipper, traffic manager, and shipping/receiving packaging supervisor. Vuk majored in Chemistry at Millersville University.

Greg Vuk

Riber annual sales up 68 percent

The MBE tool specialist still suffered due to a weak market for cells and sources

Riber has released its full-year earnings for 2012.

MBE system sales, were up 68 percent compared with 2011, reflecting the dynamic level of commercial development with compound semiconductor industrial firms and research centres.

Regarding growth, the MBE services and accessories business benefited from work carried out at the end of 2011 to further strengthen the commercial and technical organisation. So sales picked up 9 percent despite the slowdown in demand.

The cells and sources business came in lower following a flourishing 2011, marked by the delivery of major equipment orders for OLED screen production lines in Asia. This market is still buoyant for Riber.

Profitability for the year was affected by the downturn in revenues and the change in the product mix.

This trend was compounded by the year-on-year change concerning the reversal of provisions for inventories (€0.6 million in 2012, versus €1.7 million in 2011).

The gross margin came to €9.1 million (versus €12.4 million in 2011), representing 33.2 percent of revenues.

Consolidated net income totalled €1.9 million (7 percent of revenues), compared with €4.3 million in 2011 (14.8 percent of revenues).

Cash represented €5.3 million on December 31st, 2012, down €6.8 million in relation to December 31st, 2011, factoring in the impact of the seasonality of deliveries on working capital requirements, in addition to the dividend paid out for 2011, the increase in investments and the significant ramping up of research and innovation efforts.

PROPOSED DIVIDEND OF €0.04 PER SHARE

The Management Board will be submitting a proposal at the General Meeting on May 31st, 2013 for a dividend of €0.04 per share.

As recommended by the Management Board, and in order to support Riber's growth strategy, the Supervisory Board decided to co-opt new Supervisory Board members on April 3rd, 2013. These were Dominique Pons, director at GIE III-V Lab, the joint Thales, Alcatel-Lucent and CEA-Leti industrial research laboratory for III-V semiconductors and Gildas Sorin, CEO of Novaled, the German firm and world leader for developing and marketing materials for OLED production.

Their co-opting will be submitted for approval at the upcoming general meeting on May 31st, 2013.

OUTLOOK

The order book represented €15.5 million at the end of February 2013 (€12.1 million at end-2012), confirming the good level of the market for MBE research systems on which Riber is well positioned, with orders for 13 machines to be delivered in 2013.

Riber designs and produces molecular beam epitaxy (MBE) systems as well as evaporation sources and recorded €27.4 million in revenues in 2012 and employs 111 people. The company is ISO9001 certified.

Temescal tool speeds up compound semi productivity

The company's UEFC-5700 is designed for compound semiconductor production environments that use lift-off electron beam evaporation processes

The Temescal Division of Ferrotec Corporation, a global supplier of electron beam evaporation systems, has introduced the Temescal UEFC-5700.

This is a high efficiency electron beam metallisation system for lift-off compound semiconductor applications.

UEFC-5700 system

The UEFC-5700 is the first Temescal tool to incorporate the company's Auratus Deposition Process Enhancement Methodology. This technology was announced by the company in December last year.

The firm says its latest tool offers excellent uniformity while delivering up to a 40 percent increase in material collection efficiency. This results in significant cost savings on process materials like gold and platinum compared to traditional box coaters.

The UEFC-5700 features a conical shaped vacuum chamber that reduces volume and surface area, which reduces pump-down time. The system also features a patent-pending High-Uniformity Lift-off Assembly (HULA) design that uses a dual-axis motion to optimise collection efficiency.

"With the UEFC-5700, we have significantly improved the throughput efficiency of traditional lift-off coating processes. From the unique chamber design to the HULA carrier system, the UEFC-5700 improves pumping and batch capacity with excellent uniformity across all evaporated materials, enabling the system to run more wafers and more batches per day than any conventional box coater," says Gregg Wallace, managing director of Ferrotec's Temescal division.

He adds,"The biggest benefit to users of this system is the improvement in uniformity and collection efficiency of all materials being evaporated. For IDMs and foundries, this equates to improved yields of better devices that cost much less to produce. "

The Temescal UEFC-5700 offers increased wafer production capacity - the firm says up to forty-two 150mm wafers in a batch - without a significant change in raw material or energy consumption. In terms of footprint and power consumption, the UEFC-5700 is virtually identical to the FC-4400 system, Temescal's largest production system.

With its conical shaped load-locked chamber and 44,000 litres per second of installed cryogenic pumping capacity, the UEFC-5700 reaches process pressures significantly faster than many conventional box coaters.

Systems have reached 5E-07 Torr in under 10 minutes, improving production cycle times and the number of batches that can be run per shift or day.

The system incorporates Temescal's Auratus deposition process enhancement methodology. Auratus is a patent-pending proprietary optimisation methodology for lift-off electron beam evaporative coating that incorporates patent pending technology to achieve unprecedented levels of uniformity, precision, and collection efficiency.

Johnson Matthey bows out of gas purification market

This is due to a weaker LED and semiconductor market

Johnson Matthey is leaving the bulk gas purification market.

The exit regards gas purification for bulk gases using palladium membrane, heated getter or regenerable catalytic purifying technology.

Many of the products the company produces are suited to LED and compound semiconductor manufacturing.

The result will be the closure of the company's manufacturing facility in West Chester, Pennsylvania.

As a consequence, the company will begin to wind down operations at its Gas Purification Technology (GPT) business with immediate effect.

The firm also stresses to customers of Johnson Matthey's gas processing catalysts and absorbents business, which principally serves the oil, gas and chemicals sectors, that these activities are in no way related to the company's GPT business.

Johnson Matthey says it continues to stand behind its warranty obligations for previously purchased products.

Aixtron supports LED and laser research at Peking University

The institute has purchased another reactor (3 by 2 inch) to grow aluminium gallium nitride (AlGaN) based products
China's Peking University has ordered another Aixtron MOCVD reactor.

The Close Coupled Showerhead (CCS) reactor has a capacity for three 2-inch (3 x 2") substrates in a single run.

The order was made in the second quarter of 2012 with delivery scheduled for the first quarter of

2013.

Aixtron Close Coupled Showerhead (CCS) Reactor

One of the researchers who will be using the Aixtron system is Shen Bo. He says, "We already have an Aixtron CCS system in use, and we are very satisfied with it. We now needed a system to improve our UV LED and laser research. The aluminium gallium nitride (AlGaN) material growth needed for this is very challenging due to the very high temperatures of more than 1200°C required. Also AlGaN is very difficult to dope, particularly with magnesium that is used to create the *p*-type regions needed for hole injection."

Aixtron's Close Coupled Showerhead (CCS) concept is suited for small scale production and R&D. Processes are easily scaleable to larger systems. Aixtron says the stable platform comes with excellent reliability, ease of use and reproducibility.

Founded in 1898, Peking University (PKU) was the first national comprehensive university in China. At the end of the 20th century, the Chinese government placed PKU at the top of the agenda for promoting higher education, with a view to making it a world-class university by the 21st century.

Supported by the government, Peking University has made great progress in cross-disciplinary programming, talent nurturing and scientific research.

Rubicon awarded asymmetrical wafer configuration patent

The company is providing tactile and visual indicators for sapphire wafer orientation

Rubicon has been granted its "Asymmetrical Wafer Configurations and Method for Creating the Same," U.S. Patent No. 8,389,099 by the United States Patent and Trademark Office (USPTO).

The patent covers the creation of visual and tactile indicators to make sapphire wafers asymmetric according to their crystalline orientation.

Sapphire wafers have a specific orientation that is invisible to the naked eye.

Rubicon has developed a simple and elegant process to make wafers appear asymmetrical via visual or tactile inspection.

This is important as LED and semiconductor manufacturers process sapphire wafers using specific crystalline orientations.

Rubicon maintains this patent will help manufacturers in the LED and SoS / RFIC industries eliminate costly and unnecessary steps to determine orientation of sapphire wafers during processing, such as X-ray crystallography.

Epitaxy-ready wafers have either an orientation flat or an orientation notch, but this provides insufficient information. One problem is that the wafer could be flipped front-to-back and still look the same yet be unusable in that state crystallographically.

Only through repeated X-ray inspections could one ensure that no wafers are reversed. If the wafers are made asymmetrical, operators at each stage of production can verify surface orientation quickly and economically, and will be confident that the wafers have been handled correctly.

Rubicon's patent demonstrates several different solutions

for making sapphire wafers asymmetric.

One scenario is a rounded corner on the orientation flat or notch which allows a user to easily determine that the wafer has not been reversed. In another solution, both corners of the flat are rounded to different radii.

These differences are enough to determine orientation by touch or visual inspection. The technique can be applied to other substrates including silicon, silicon oxide, AlN, germanium, SiC, GaAs, GaP, GaN, and amorphous analogues.

“This new patent demonstrates our ongoing commitment to refine our products for our customers and deliver innovations that deliver real value,” says Raja M. Parvez, President and CEO of Rubicon Technology. “For Rubicon’s customers in the LED and SoS / RFIC markets, the crystal orientation is a critical factor in their manufacturing processes. This patent provides a simple and elegant solution to eliminating costly mistakes in the processing of sapphire wafers.”

“It underscores our dedication to not only provide high quality sapphire wafers, but to provide our customers with added value to lower the total cost of LED and RF solutions,” he adds.

StellarNet goes viral with InGaAs Raman spectrometers

The firm’s latest detectors which use indium gallium arsenide, offer benefits over silicon based detectors which can suffer from saturation and bloom

StellarNet has released a series of portable Raman spectrometers that utilise InGaAs detectors to capture NIR spectra induced by 1064nm lasers.

Sample fluorescence is avoided while the SpectraWiz software enables quick identification of liquids, powders, or solids.

StellarNet InGaAs spectrometer

Fluorescence interference can be a problem with 830nm, 785nm and lower frequency lasers especially with organic materials. Silicon CCD detectors get saturated and bloom preventing Raman spectra from being extracted.

Stellarnet’s high resolution model (Raman-HR-TEC-IG) achieves 8cm-1 resolution with a 1024 element PDA detector, while its standard resolution instrument achieves 16cm-1 and has a 512 PDA.

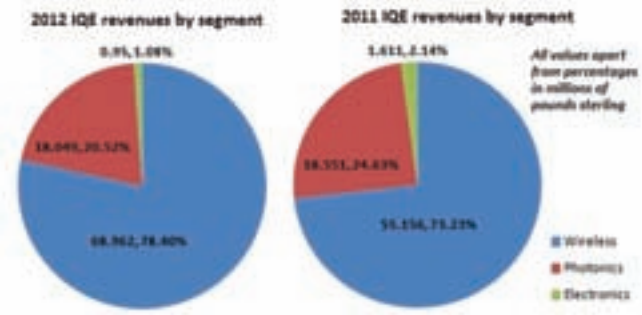
Both instruments have integrated 2 stage TEC (Thermo Electric Coolers). These instruments have no moving parts and are permanently aligned for shock-proof durability. SMA-905 optical input to spectrometer allows attachment of Raman probes or fibre optic sample accessories.

StellarNet says its hardy compact spectrometers are suited to both portable lab and field applications. Each has a PC interface via USB2 cable for power and data and includes +5VDC adapter for TEC cooler - battery pack option available for TEC.

IQE’s financials hike thanks to diversifying

The group says it has been transformed by three strategic transactions, making the firm well positioned to exploit its position in growing markets. These include co-operations with Solar Junction, RFMD and Kopin

IQE plc, a global supplier of wafer products and services to the semiconductor industry, has announced its final results for the year ended 31st December 2012.



Revenues increased 17 percent to £88 million, up from £75.3 million in 2011. The second half of 2011 was particularly strong and up 45 percent to £53.7 million from H2 2011 revenues of £37 million.

In the second half of 2012, EBITDA increased by 56 percent to £12.2 million from £7.8 million in the second half of 2011.

CAPEX was £13.1 million, down from 2011, when it was £17.4 million but the firm says this was down to its completion of its two year capacity expansion programme.

Drew Nelson, IQE Chief Executive was very proud of the company's results, and made a long statement. He said:

"IQE has been transformed over the last 14 months. Three major transactions, the completion of our capacity expansion programme and the achievement of a number of significant qualifications in both wireless and photonics (optoelectronics) have laid the foundations for accelerated growth in 2013 and beyond."

"Financially, our record second half performance in 2012 has provided a glimpse of what's to come. Furthermore, the strengthening of our risk mitigation strategy reduces the potential for short-term customer demand volatility."

"The road ahead has never been clearer. The advanced properties of compound semiconductors are central to addressing the challenges and performance expectations facing the electronics industry. This is a matter of fundamental physics as the next wave of growth for the electronics industry will be enabled by combining the properties of advanced compound semiconductors with the cost advantages of silicon. This is already beginning to happen and will accelerate in the next few years."

"As IQE is at the forefront of this trend, we are increasingly confident that the Group is well positioned for strong growth in 2013 and beyond. Therefore our focus now is on delivery. The current financial year has started well, in line with the Board's expectations, with the momentum seen in the second half of 2012 continuing."

Aixtron appoints new lab director in China

MOCVD reactor manufacturer's training and demonstration centre in Suzhou has appointed Qingshan Li to lead the team

Aixtron SE's Training and Demonstration Centre in Suzhou, China, has reached its next planning stage.

In March 2013 Qingshan Li took over the responsibility as Director of Process Support at Aixtron China from Nicolas Muesgens, who has built up and led the centre since its opening a year ago.

The new director in Aixtron's plant in Suzhou, Qingshan Li

"I am proud of what we have achieved," Nicolas Muesgens comments. "Customers benefit immensely from seeing and evaluating real process runs in Suzhou without having to interrupt their own production line. This enables customers to increase their efficiency by avoiding lost productivity."

Tim Wang, General Manager Aixtron China adds, "We thank Nicolas for having done such a great job in launching the centre. In the future, our lab will be even more tailored to our customers' needs. Most of Aixtron's key customers attended a training session during this first year of operation. Their feedback confirm that it is very helpful and effective to have real process demos with training capabilities locally, close to our customers."

The newly appointed Director Qingshan Li received his Ph.D. in material science from the East China University of Science and Technology (ECUST) in Shanghai. Before joining Aixtron he held several positions in the field of process engineering at Novellus Systems, most recently

as Director Process & Technology.

"My goal is to continue accelerating the drive to increased tool stability and productivity under mass production at our customers´ sites in China with high-quality training in Suzhou," Qingshan Li comments.

"Several customer process demos with major Chinese customers on the CRIUSII-XL are scheduled. For training purposes, a new CRIUS II-XL system trolley reactor will be added and made available to bring the technology even closer to our customers, significantly intensifying our hands-on hardware training. Both of our latest MOCVD systems will have been equipped with advanced features in the 1st half of 2013, e.g. the AIX G5 system with GaN-on-Si capability."

Maximising batch production for HBLEDs with Oxford's tool

The etch solution for GaN, AlGaInP and PSS will offer HBLED production manufacturers high throughput coupled with excellent CoO

Oxford Instruments Plasma Technology has just announced an evolution in batch etch technology with the launch of the PlasmaPro1000 Astrea etch system.

This is a large batch etch solution for PSS, GaN and AlGaInP that will offer HBLED production manufacturers high throughput coupled with industry leading Cost of Ownership (CoO).

PlasmaPro1000 Astrea etch system

The launch is being made at the LED China exhibition in Shanghai this week, where Mark Dineen, Oxford Instruments HBLED Product Manager will present the new system to the LED China Conference delegates.

"The PlasmaPro1000 Astrea is our ultimate batch etch tool, building on over 15 Years experience as a major supplier to the HBLED industry", says Mark Dineen, Oxford Instruments Plasma Technology's HBLED Product Manager, "Today's HBLED manufacturers justifiably demand high yield, high throughput, optimum device quality and low cost of ownership. Our PlasmaPro1000 Astrea large batch etch system offers solutions for all of these."

With wafer batch sizes from 55 x 2" to 3 x 8", the system has been designed specifically for the harsh chemistries required for HBLED materials. Oxford says the PlasmaPro1000 Astrea delivers low damage, high yield processes ensuring the maximum light output from customers' chips.

This highly configurable system, with process chambers that are available as standalone modules or in cluster configurations, available on a four sided cluster tool are capable of supporting up to three process modules.

Designed to ensure high system availability and ease of serviceability, key system features and benefits include over 690mm large area source for highly uniform plasma.

The 490mm electrode is claimed to give unparalleled throughput from batch sizes of 55 x 2", 14 x 4", 7 x 6" and 3 x 8". The tool also has a high conductance pumping system and a dual entry gas inlet for ease of process tuning.

What's more, clamping for wafer cooling is maximised and the system has a *z*-movement electrode for ultimate uniformity. Oxford claims that the reliable hardware and ease of serviceability allows for excellent uptime.

Dan Ayres, Managing Director of Oxford Instruments Plasma Technology comments, "This advanced and innovative system has been developed to address the exacting needs of HBLED Production users, who demand not only the very latest technological innovations, but also the superb customer support offered by our company."

"As an industry leading manufacturer of systems for plasma etch and deposition, Oxford Instruments constantly strives to improve and evolve its systems to provide the ultimate tool. With access to our exclusive library of over 6,000 process recipes, built up over 25 years as a leading plasma tool manufacturer, our customers are guaranteed an excellent product with comprehensive, market leading backup," he concludes.

Imec announces launch of integrated silicon photonics platform

Platform enables cost-effective R&D of silicon photonic ICs for high-performance optical transceivers

Nanoelectronics research centre Imec has announced the launch of its fully integrated silicon photonics platform through a cost-sharing Multi-Project Wafer (MPW) service via ePIXfab*. The platform enables cost-effective R&D of silicon photonic ICs for high-performance optical transceivers (25Gb/s and beyond) and optical sensing and life science applications. The offered integrated components include low-loss waveguides, efficient grating couplers, high-speed silicon electro-optic modulators and high-speed germanium waveguide photo-detectors.

Since 2007, imec and its associated laboratory at Ghent University have been offering a platform for passive silicon photonic components via ePIXfab*, for R&D under shared cost conditions. Now, imec extends its silicon photonics offering, using a standard130nm CMOS toolset, with active components such as high-speed optical modulators and integrated germanium photo-detectors.

“Imec’s Silicon Photonics platform provides robust performance and solutions to integrated photonics products in medical diagnostics, telecom and datacom industries. Companies can benefit from our silicon photonics capability through established standard cells, or explore the functionality of their own designs in MPW,” stated Philippe Absil, program director at imec. “This Silicon Photonics MPW offer provides a cost-efficient solution, with state-of-the-art performance, design flexibility and superior CD and thickness control”.

The first run opens for registration with tape-in on 9th of Oct 2013 and first devices will be out in May 2014. Support, registration and design kit access will be organized by Europractice IC service, in collaboration with world-wide MPW partners.

Imec’s Si Photonics 200mm wafer platform offers extensive design flexibility and includes –

• Tight within-wafer silicon thickness variation 3sigma < 2.5nm

• 3-level patterning of 220nm top Si layer (193nm optical lithography)

• poly-Si overlay and patterning (193nm optical lithography)

• 3-level n-type implants and 3-level p-type implants in Si

• Ge epitaxial growth on Si and p-type and n-type implants in Ge

• Local NiSi contacts, Tungsten vias and Cu metal interconnects

• Al bond pads

• Validated cell library with fiber couplers, polarization rotators, highly efficient carrier depletion modulators and ultra-compact Ge waveguide photo-detectors with low dark current.

• Design kit support for Ipkiss, PhoeniX and Mentor Graphics software

About ePIXfab

*ePIXfab is the European Silicon Photonics Platform co-funded by the EU. ePIXfab is a consortium of partners coordinated by imec-UGent partnership. Other members of the consortium are CEA-LETI (France), IHP (Germany) TNO (Netherlands), Tyndall (Ireland), VTT (Finland) and CMC Microsystems (Canada); providing together diverse expertise from design to packaging thus supporting the emergence of a fabless ecosystem in Silicon Photonics.

Fraunhofer IAF chooses Veeco GEN200 MBE system

The tool will be used for research and development of various antimonide and arsenide-based III-V optoelectronic devices

The Fraunhofer Institute for Applied Solid State Physics IAF, an institution specialising in the field of compound semiconductor research in Freiburg, Germany, has purchased a Veeco MBE GEN200 reactor.

According to Martin Walther, Head of Infrared Detectors Business Unit at Fraunhofer IAF, “We have been working with Veeco for more than a decade, and have had very good experiences with the existing Veeco MBE systems in our facility. Thus we decided in favour of Veeco’s fully automated production MBE systems as demand for epitaxial layers for antimonide based III-V optoelectronics has increased.”

Jim Northup, Vice President, General Manager of Veeco’s MBE Operations, adds, “This new purchase extends our longstanding collaborative relationship with Fraunhofer IAF, one of the world’s top research facilities

in the field of III-V semiconductors. Our GEN200 is known for its lowest cost 4 x 4" epiwafer growth and it is the ideal tool to support Fraunhofer IAF's expansion in growth services."

The GEN200 is a cost-effective and highest capacity multi - 4" production MBE system. It is claimed to deliver superior throughput, long campaigns and excellent wafer quality in growing GaAs or InP-based wafers for such devices as pump lasers, VCSELs and HBTs.

Riber receives Russian research reactor order

The MBE tool will be used for the preparation of silicon and germanium-based thin nanostructured layers

MBE system provider Riber has sold a SIVA 21 research system to the Institute of Automation and Control Processes (IACP), part of the Russian Academy of Sciences in Vladivostok.

This machine will be set up in the optoelectronics and electronics physics research centre headed by Nicolay Galkin. It will enable the laboratory to ramp up its semiconductor research capabilities, focusing in particular on the preparation of silicon and germanium-based thin nanostructured layers.

The Russian Academy of Sciences is the umbrella organisation for Scientific Institutes in the Russian Federation. More specifically, it is very active in the semiconductor physics field.

Riber says its 21 Series systems offer unrivalled flexibility for use making it possible to meet the most demanding expectations for applied research on compound semiconductor materials.

The company believes this new order consolidates Riber's development in Russia, where the semiconductor industry is developing strongly.

Novel Devices

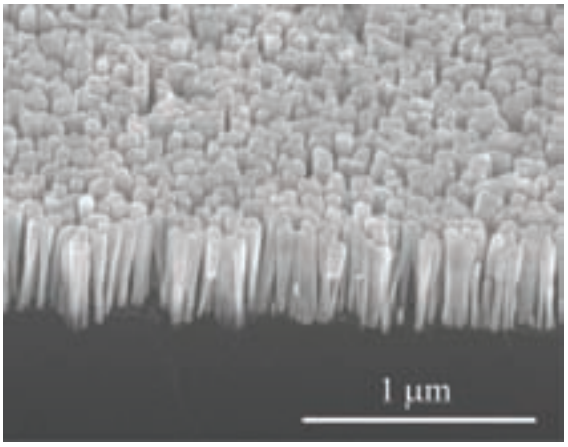
Nanowires boost efficiency of solar cells

ZnO quantum dots could translates fabrication of large-area films making solar panels

Solar cells made from quantum dots could be low-cost, flexible, and easy to make.

But the efficiency with which they convert light into electricity remains too low for practical use. Capitalising on the, researchers' at the Massachusetts Institute of Technology have orating nanowires into quantum dot solar cells.

The cell's efficiency increases the cells' efficiency by 35 percent. Quantum dots are semiconductor nanocrystals that absorb different wavelengths of light depending on their size.



Electron micrograph of the nanowire/quantum dot solar cell. (Credit: Joel Jean et al, Bulovic)

Solar cells made from different-sized crystals should absorb light over a much wider range of colours than silicon devices.

What's more, because quantum dots are made in solution, they could be easily printed or painted onto flexible surfaces. Scientists have calculated that quantum dots could be used to make thin-film solar cells that could convert light to electricity with 15 percent efficiency, the same as commercial silicon devices.

The best-performing quantum dot solar cells consist of a lead sulphide quantum dot layer butted up against a zinc oxide or titanium dioxide layer. The quantum dots absorb light, and electrons created in the process travel to the metal oxide layer to reach the electrical circuit.

The problem is that the quantum dot layer has to be thick enough to absorb light efficiently, but thin enough for the electrons to quickly traverse it.

The MIT researchers, led by electrical engineering and computer science professor Vladimir Bulovic, overcame that trade off by replacing the flat ZnO layer with an array of vertical zinc oxide nanowires.

nanowires penetrate the quantum dot layer, providing conductive paths for the electrons to follow out to the electrical circuit, says Joel Jean, a graduate student in Bulovic's group. The researchers published their results

in the journal Advanced Materials.
The researchers start with glass substrates that are coated with indium tin oxide transparent electrodes. They deposit a ZnO layer on top and float the entire susbtrate upside down in an aqueous solution of zinc precursors.

An array of aligned nanowires grows downwards from the ZnO layer. After about an hour, the researchers rinse the substrates. Finally, they deposit PbS quantum dots, which fill up the space between the nanowires, and top it off with a gold electrode.

The nanowires boost the output current of the devices by 50 percent and the efficiency by 35 percent over planar ZnO devices. The overall light-to-electricity conversion efficiency of the new devices is 4.9 percent, among the highest reported for ZnO-based quantum dot solar cells, Jean says.

The researchers believe the efficiency could be further enhanced by using thicker light-absorbing layers and longer nanowires, as well as by controlling the spacing between nanowires to better accommodate quantum dots.

The idea of using ZnO nanowires to increase efficiency in quantum dot solar cells is not new, but this is the first significant implementation of the concept, says Matthew Beard, a senior scientist at the National Renewable Energy Laboratory. “The observed efficiency boost is promising and significant,” he says. “The efficiencies for these types of solar cells are increasing rapidly and this work demonstrates that the improvements in efficiency will continue.”

A key advantage of the nanowire-quantum dot cells, says Jean, is that they could be made on large areas. “One of the main benefits of quantum dots is that they’re grown in and deposited from solution,” he says.

“This translates to fabrication of large-area films, which is necessary for making solar panels. Zinc oxide nanowires are also grown in an aqueous solution process. Scalability should be one of the primary practical advantages of this type of solar cell”.

Optimising the harvesting of sunlight

A gallium nitride based single-photon emitter can secure communication

University of Michigan researchers have developed a new device that could make the advanced form of secure communications known as quantum cryptography more practical.
The U-M scientists have demonstrated a simpler, more efficient single-photon emitter that can be made using traditional semiconductor processing techniques.

Single-photon emitters release one particle of light, or photon, at a time, as opposed to devices like lasers that release a stream of them.

Single-photon emitters are essential for quantum cryptography, which keeps secrets safe by taking advantage of the so-called observer effect: The very act of an eavesdropper listening in jumbles the message. This is because in the quantum realm, observing a system always changes it.

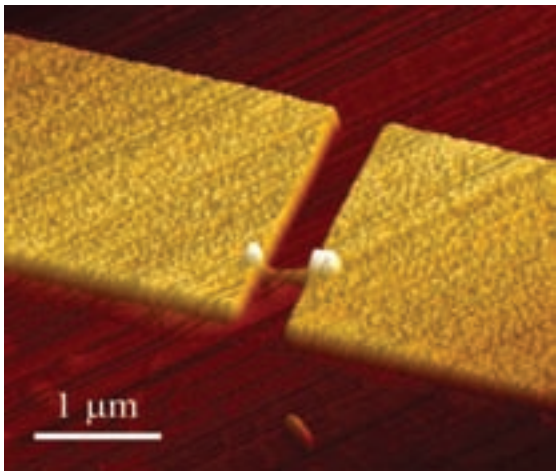
For quantum cryptography to work, it’s necessary to encode the message - which could be a bank password or a piece of military intelligence, for example - just one photon at a time. That way, the sender and the recipient will know whether anyone has tampered with the message.

While the U-M researchers didn’t make the first single-photon emitter, they say their new device improves upon the current technology and is much easier to make.

“This thing is very, very simple. It is all based on silicon,” says Pallab Bhattacharya, the Charles M. Vest Distinguished University Professor of Electrical Engineering and Computer Science, and the James R. Mellor Professor of Engineering.

Bhattacharya, who leads this project, is a co-author of a paper on the work published in *Nature Communications* on April 9th.

Bhattacharya’s emitter is a single nanowire made of gallium nitride (GaN) with a very small region of indium gallium nitride (InGaN) that behaves as a quantum dot. A quantum dot is a nanostructure that can generate a bit of information. In the binary code of conventional computers, a bit is a 0 or a 1. A quantum bit can be either or both at the same time.



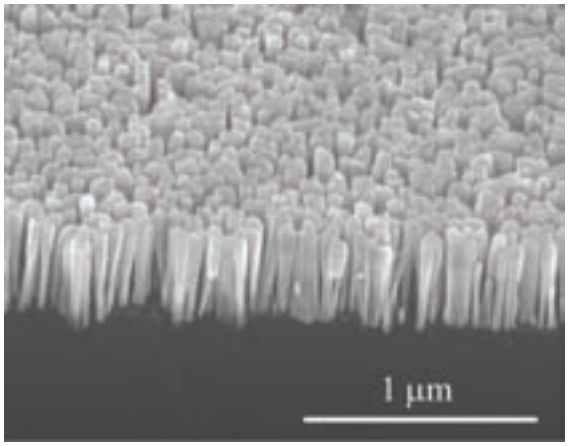
An atomic force microscope image of a nanowire single photon emitter. (Courtesy of Pallab Bhattacharya)

The semiconducting materials the new emitter is made of are commonly used in LEDs and solar cells.

The researchers grew the nanowires on a silicon wafer. Because their technique is silicon-based, the infrastructure to manufacture the emitters on a larger scale already exists. Silicon is the basis of modern electronics.

"This is a big step in that it produces the pathway to realising a practical electrically injected single-photon emitter," Bhattacharya says.

Key enablers of the new technology are size and compactness.



SEM image of nanowires growing on silicon. (Courtesy of Pallab Bhattacharya)

"By making the diameter of the nanowire very small and by altering the composition over a very small section of it, a quantum dot is realised," Bhattacharya explains. "The quantum dot emits single-photons upon electrical excitation."

The U-M emitter is fuelled by electricity, rather than light - another aspect that makes it more practical. And each photon it emits possesses the same degree of linear polarisation. Polarisation refers to the orientation of the electric field of a beam of light. Most other single-photon emitters release light particles with a random polarisation.

"So half might have one polarisation and the other half might have the other," Bhattacharya says. "So in cryptic message, if you want to code them, you would only be able to use 50 percent of the photons. With our device, you could use almost all of them."

This device operates at cold temperatures, but the researchers are working on one that operates closer to room temperature.

Further details of this work are in the paper, "Electrically-driven polarized single-photon emission from an InGaN quantum dot in a GaN nanowire," by S. Deshpande *et al* in *Nature Communications*, 2013, 4. 1675. DOI: 10.1038/ncomms2691

The work is supported by the National Science Foundation. The device was fabricated at the U-M Lurie Nanofabrication Facility.

QMC & DOE collaborate on tetrapod quantum dot research

Quantum Materials Corporation has recently developed and delivered customised tetrapod QD samples for applications being developed by the US Department of Energy National Lab researchers.

As one of the largest sponsors of U.S. technical and military research, the DOE helps to move innovative technologies into the commercial marketplace, creating new jobs and future industries.

Quantum Materials Corporation (QMC) has also agreed to supply customised tetrapod quantum dots to a U.S. government defence related agency in support of a nano-biological project.

More than 110 science-related Nobel Prizes have been awarded to DOE-associated researchers.

Department of Energy National (DOE) Labs, Energy Innovation Hubs and Technology Centres are developing quantum dot and other nanoscale applications.

Relevant applications include solar photovoltaics, batteries, biofuels, physics and biological sciences.

One institute working on the project is Los Alamos National Lab (LANL), which is exploring quantum dot-fluorescent proteins (QD-FP) in devices. They use pH-sensitive fluorescent protein acceptors to produce long-lived sensors for biological imaging. LANL's use of quantum dots for precise cellular imaging produces valuable data for the hopeful cure or treatment of many diseases and conditions.

QMC believes its technology meets three NNI National Signature Initiatives objectives. These are new advanced materials (tetrapod quantum dots), mass production (continuous flow process) and nanomanufacturing (roll-to-roll printing).

Stephen Squires , QMC CEO comments, "The many DOE National Labs are in the forefront of quantum dot research and we welcome the opportunity to collaborate with them. QMC has enabling technologies to help fulfill NNI National Signature Initiatives years ahead of forecasts, advancing the nation's research rapidly while perhaps saving the U.S. Government millions that can be redirected to application development."

QMC currently offers high-brightness cadmium-based and ecological cadmium-free non-heavy metal tetrapod QD and can synthesise many Group II-VI inorganic mono or hybrid tetrapod quantum dots.

The firm intends to build out its quantum dot production facilities in the U.S. with full commercial production expected in the fourth quarter of 2013.

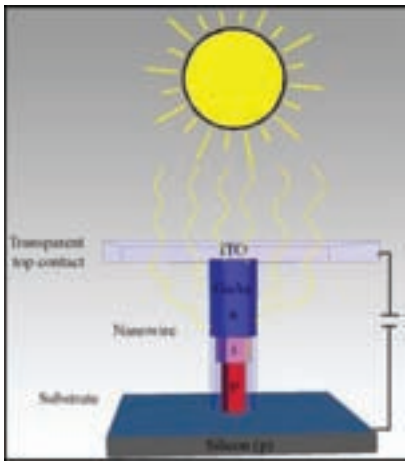
GaAs nanowire solar cells have massive potential

Cylindrical III-V nanowire structures are predicted to have great potential in the development of solar cells, quantum computers and other electronic products

Scientists have shown that a single nanowire can concentrate the sunlight by up to 15 times of normal sunlight intensity.

The researchers who made the discovery come from the Nano-Science Centre at the Niels Bohr Institut, Denmark and the Ecole Polytechnique Fédérale de Lausanne, Switzerland.

Surprised with the results, the team believe their latest data shows the potential for developing a new type of highly efficient solar cell.



Above, the sun's rays are drawn into a nanowire, which stands on a silicon substrate. At a given wavelength the sunlight is concentrated by up to 15 times (Credit: Niels Bohr Institute)

Due to some unique physical light absorption properties of nanowires, the limit of how much energy can be utilised from the sun's rays is higher than previously believed, say the researchers.

These results demonstrate the great potential of development of nanowire-based solar cells says Peter Krogstrup, a Ph.D. scientist who worked on the project and is one of the authors of a recent paper published in *Nature Photonics.*

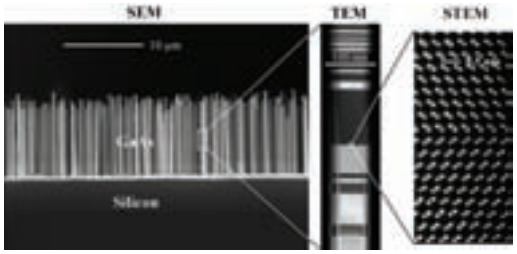
In the past few years, the project researchers have developed and improved the quality of the nanowire crystals. These crystals have a cylindrical structure with a diameter of about 10,000 part of a human hair.

The team members believe their nanowire technology could have great potential in the development of not only solar cells, but also next generation quantum computers and other electronic products.

It turns out that the nanowires naturally concentrate the sun's rays into a very small area in the crystal by up to a factor 15.

And because the diameter of a nanowire crystal is smaller than the wavelength of the light coming from the sun, it can cause resonances in the intensity of light in and around nanowires.

Peter Krogstrup points out the resonances concentrate the sunlight, leading to a higher conversion efficiency of the sun's energy.



Various microscope images of the GaAs nanowire structure

New efficiency limit

The typical efficiency limit - the so-called “Shockley-Queisser Limit,” has for many years been a landmark for solar cell efficiency among researchers, but now it seems that it may be increased.

The scientists point out that their exciting discovery could move the theoretical limits. And moving the limit by only a few percent should have a major impact on the development of solar cells, exploitation of nanowire solar rays and perhaps the extraction of energy at international level.

However, it will take some years before production of solar cells consisting of nanowires becomes a reality, acknowledges Krogstrup.

This research was conducted in collaboration with the Laboratory des Matériaux Semiconducteurs, Ecole Polytechnique Fédérale de Lausanne, the Foundation and the company SunFlake A / S.

The scientific findings reported here support results published in the journal *Science* in January. Here, a group of researchers from Lund, showed that the sun’s rays was sucked into the nanowires due to the high amount of power that their solar cell produced.

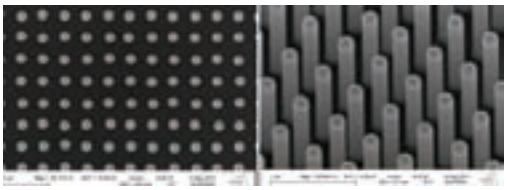
InP nanowires propel solar cells

An indium phosphide nanowire solar cell can produce an effect per active surface unit several times greater than today’s silicon cells

Researchers from Lund University in Sweden have shown how InP nanowires could pave the way for more efficient and cheaper solar cells.

“Our findings are the first to show that it really is possible to use nanowires to manufacture solar cells,” says Magnus Borgström, a researcher in semiconductor physics.

Research on solar cell nanowires is on the rise globally. Until now the unattained dream figure was ten per cent efficiency - but now Borgström and his colleagues are able to report an efficiency of 13.8 percent.



Characterisation of NW-array solar cells: 0° (left) and 30° (right) tilt scanning electron microscopy (SEM) images of as-grown InP NWs with a surface coverage of 12 percent

The nanowires are made of InP and work like antennae that absorb sunlight and generate power. The nanowires are assembled on surfaces of one square millimetre that each house four million nanowires.

A nanowire solar cell can produce an effect per active surface unit several times greater than today’s silicon cells.

Nanowire solar cells have not yet made it beyond the laboratory, but the plan is that the technology could be used in large solar power plants in sunny regions such as the south-west of thr USA, southern Spain and Africa.

The Lund researchers have now managed to identify the ideal diameter of the nanowires and how to synthesise them.

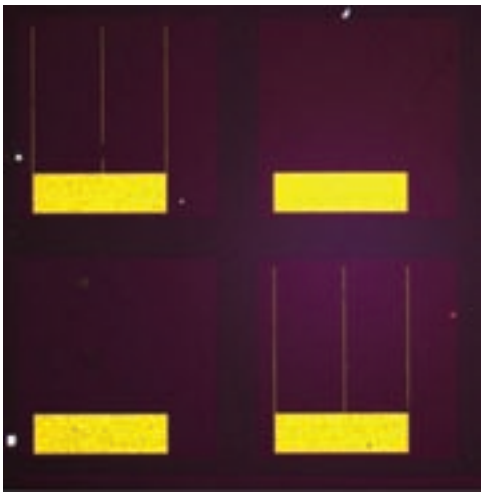
“The right size is essential for the nanowires to absorb as many photons as possible. If they are just a few tenths of a nanometre too small their function is significantly impaired,” explains Magnus Borgström.

The silicon solar cells that are used to supply electricity for domestic use are relatively cheap, but inefficient because they are only able to utilise a limited part of the effect of the sunlight. The reason is that one single material can only absorb part of the spectrum of the light.

Research carried out alongside that on nanowire technology therefore aims to combine different types of semiconductor material to make efficient use of a broader part of the solar spectrum.

The disadvantage of this is that they become extremely expensive and can therefore only be used in niche contexts, such as on satellites and military planes.

However, this is not the case with nanowires.



Optical microscope image of NW solar cells

Because of their small dimensions, the same sort of material combinations can be created with much less effort, which offers higher efficiency at a low cost.

The process is also less complicated. The researchers have shown that the nanowires can generate power at the same level as a thin film of the same material, even if they only cover around 10 per cent of the surface rather than 100 percent.

The research was carried out as part of an EU-funded project, AMON-RA, coordinated by Knut Deppert, Professor of Physics at Lund University.

“As the coordinator of the project, I am very proud of such a great result - it has well exceeded our expectations. We will of course continue the research on nanowire solar cells and hope to achieve an even higher level of efficiency than the 13.8 per cent that we have now reported,” concludes Knut Deppert.

Further details of this work have been published in the paper, “ InP Nanowire Array Solar Cells Achieving 13.8% Efficiency by Exceeding the Ray Optics Limit,” by M. Borgström *et al*in*Science*1230969. DOI:10.1126/science.1230969